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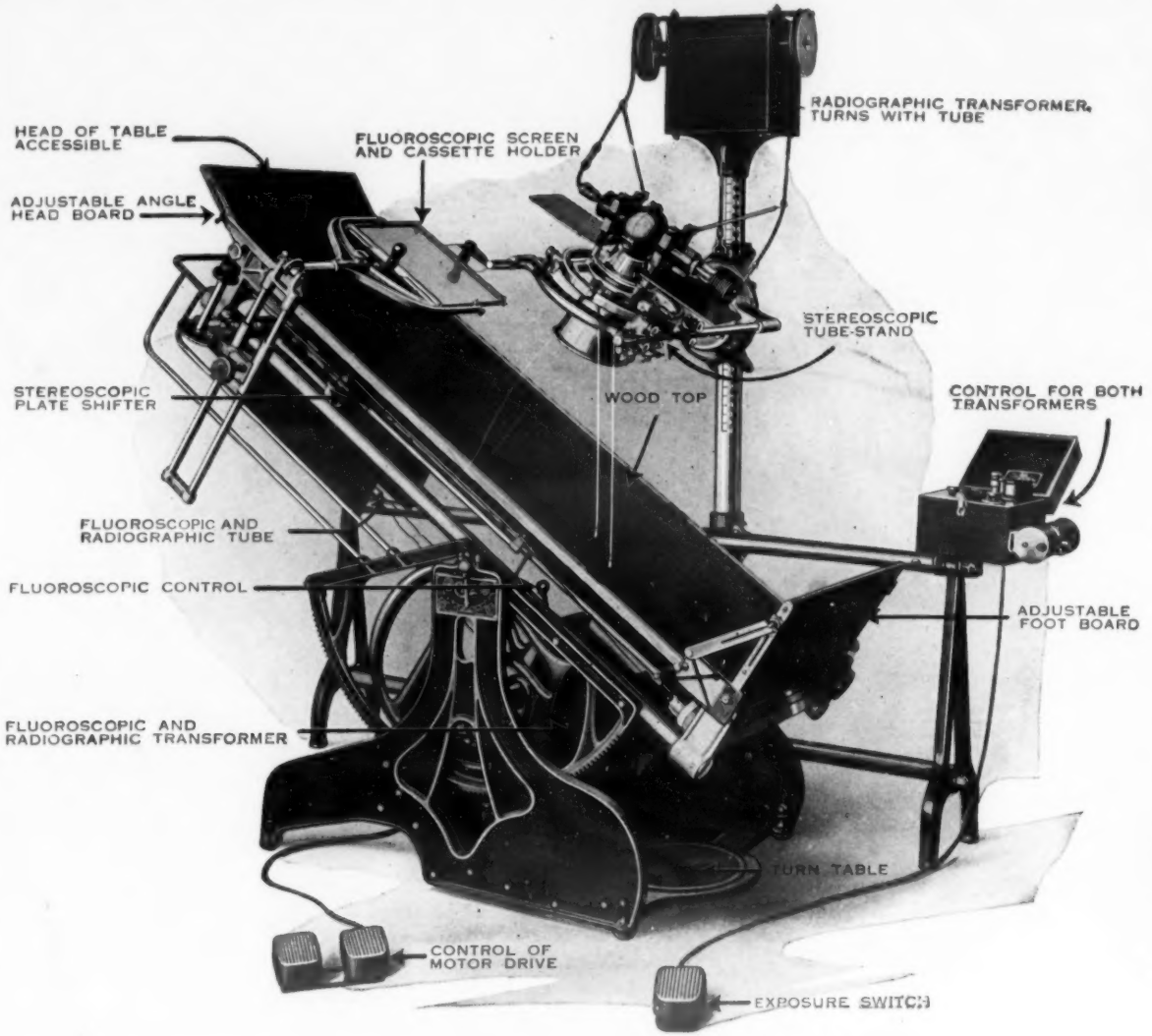

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ROENTGEN RAYS AND RADIUM IN THE DIAGNOSIS AND TREATMENT OF CARCINOMA OF THE PROSTATE*

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THE favorable results reported by Pasteau and Degrais (1910) in the treatment of cancer of the prostate by radium inspired the hope that a satisfactory treatment for this condition had been discovered. Since then many others have reported similar results, but such reports have been made too soon after treatment, or the series of cases reported has been too small on which to base judgment. Neither have there been series of cases reported of what might be termed normal or untreated cases with which to compare results. Thus it has been difficult to judge accurately the results obtained with the use of radium.

The series of 646 cases of carcinoma of the prostate which I shall report is sufficiently large to afford statistical data of value with regard to the various forms of treatment employed, especially radium. Until within recent years correct diagnoses in cases of cancer of the prostate were often not made unless the patients were operated on. Thus many cases were classified as benign hypertrophy which were undoubtedly malignant.

During the past three years 1,641 patients with prostatic enlargement were examined. In 260 of these (15.84 per cent) the prostates were malignant, a percentage which I believe is accurate and indicative of the prevalence of the disease. In the series of 646 patients the prostate was removed in 146, no form of treatment was employed in 325; the remaining 197 patients were treated by radium. The statistics in the first two groups afford a basis on which the results of radium treatment in the 197 patients may be compared.

The results of surgical treatment are tabulated in Table 1.

DISCUSSION OF TABLE I

The fact that 80 per cent of the patients died within two years after operation and that of the sixteen patients who lived more than three years only seven are alive, explains the readiness with which surgeons relinquished this group of cases to radium treatment.

Just as in the past, reports of the results of surgical treatment were made too soon after operation to be accurate, so in the present the reports of the results of radium treatment are made too soon to afford accurate data. It is evident that in order to judge accurately the various forms of radium treatment it is fairer to compare data from a series of patients who have not been treated than from a series of patients treated surgically, who were in good physical condition and in whom the disease was not far advanced.

The group of 325 untreated patients includes patients in all stages of the disease and represents the type that have

* Due to the great length of the paper awarded the Leonard Prize, the Committee decided not to publish it in the JOURNAL. Certain of the other papers which were awarded Honorable Mention, of which this is one, will be published.

TABLE I

ONE HUNDRED FORTY-SIX PATIENTS OPERATED ON

Operative Mortality 5.5 Per Cent

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Prostatectomy**		*Average Length of Life After Operation, Months*	*Average Age, Years*
				Perineal	*Suprapubic*		
Heard from	120	.....	62.36	42	75	24.86	64.27
Dead	96	80.0	51.3	41	52	21.72	64.95
Living	24	20.0	80.2	1	23	35.2	63.58
Patients who lived							
1– 12 months	41	34.16	40.4	19	22	6.18	65.8
13– 24 months	23	19.16	45.95	8	15	18.86	63.13
25– 36 months	14	11.66	56.64	8	6	38.14	65.07
37– 48 months	1	0.83	168.0	1	0	41.0	62.0
49– 60 months	3	2.5	77.33	1	2	53.3	65.0
61– 72 months	2	1.66	95.5	1	1	70.0	60.5
85– 96 months	1	0.83	168.0	1	0	96.0	64.0
97–108 months	2	1.66	156.0	0	2	103.5	72.0
Not stated	9	7.5	.....	2	4		
Patients living							
1– 12 months	4	3.33	66.75	0	4	10.2	64.75
13– 24 months	8	6.66	67.85	0	8	19.87	66.25
25– 36 months	5	4.16	71.0	0	5	31.8	61.4
37– 48 months	1	0.83	87.0	0	1	48.0	69.0
49– 60 months	2	1.66	83.0	0	2	52.5	53.5
61– 72 months	2	1.66	83.0	0	2	67.5	59.0
73– 84 months	1	0.83	139.0	0	1	78.0	75.0
109–120 months	1	0.83	174.0	1	0	120.0	61.0

* Operation not stated in three cases.

TABLE II

THREE HUNDRED TWENTY-FIVE PATIENTS NOT TREATED

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*With Metastasis*	*Without Metastasis*	*Average Length of Life After Examination, Months*	*Average Age, Years*
Heard from	231	.....	34.59	55	176	11.8	64.84
Dead	215	93.0	32.82	52	163	9.58	64.71
Living	16	6.9	59.15	3	13	39.06	66.6
Patients who lived							
1– 12 months	149	64.5	29.1	42	107	4.97	64.34
13– 24 months	32	13.85	41.66	9	23	17.53	65.18
25– 36 months	8	3.46	46.28	0	8	28.37	67.5
37– 48 months	3	1.29	75.0	0	3	44.3	67.0
49– 60 months	2	0.86	68.0	0	2	52.0	68.5
73– 84 months	1	0.43	.....	0	1	78.0	69.0
Not stated	20	8.65	.....	1	19	.....	.....
Patients living							
1– 12 months	4	1.73	10.0	1	3	19.3	66.5
13– 24 months	4	1.73	32.7	2	2	19.75	68.7
25– 36 months	1	0.43	149.0	0	1	29.0	70.0
37– 48 months	2	0.86	120.0	0	2	47.0	68.5
49– 60 months	1	0.43	49.0	0	1	49.0	66.0
61– 72 months	2	0.86	73.0	0	2	70.0	63.5
73– 84 months	1	0.43	.....	0	1	79.0	63.0
108–120 months	1	0.43	144.0	0	1	118.0	62.0

been treated with radium. Information has been received concerning 231 of these (71 per cent), thus affording an opportunity to study the disease when its course was not altered by treatment and to compile accurate statistics as a basis of comparison with the results of several methods of radium treatment.

DISCUSSION OF TABLE II

The noteworthy fact in this series is that the patients who died, and in whom, therefore, the disease had run its course, lived an average of 9.58 months after they were examined and an average of 32.82 months from the time of their first symptoms; this may be considered representative of the average duration of the disease. The sixteen patients (6.9 per cent) who are still alive constitute two types, those who have recently refused treatment and who have not lived out their allotted 32.82 months, and those whose cases were wrongly diagnosed. This percentage seems remarkably low when it is considered that the diagnoses were all made by palpation alone and were not checked up by pathological findings as were the diagnoses in the surgical group. The low percentage is undoubtedly due to the fact that when the diagnosis was in doubt the patient was given the benefit and operation was performed. It does not seem legitimate, however, to use these percentages as a basis of comparison in ascertaining the results of radium treatment, since fifty-five of the patients had metastasis at the time of their examination.

While opinions differ concerning whether or not radium and the roentgen ray treatments are beneficial in cases in which metastasis has occurred, I believe that all observers are agreed with regard to the influence of metastasis on prognosis.

DISCUSSION OF TABLE III

The influence of metastasis on prognosis is illustrated in the group of fifty-five patients, 94.54 per cent of whom died on an average of 7.72 months after their examinations, two months earlier than the average. It is probable that the majority of patients with carcinoma of the prostate develop metastasis some time before death, but in some this occurs early and the presence of many such patients in this group explains the shortening of the average duration of the disease, which was 29.25 months, four months less than the average.

It may also be noted that the average age of these patients, 63.5 years, is below the general average of the patients with the disease.

The fact that 76.36 per cent of these patients died during the ensuing years is sufficient evidence of the hopelessness of the condition. Palliative treatment, such as the roentgen ray or radium, was not attempted in these cases. The smallness of this group, consisting of 27.6 per cent of the patients examined, is evidence that

TABLE III

NINETY PATIENTS WITH METASTASIS

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Length of Life After Examination, Months*	*Average Age, Years*
Heard from	55	.....	28.78	8.15	63.4
Dead	52	94.54	29.25	7.72	63.5
Living	3	5.45	21.3	15.0	64.0
Patients who lived					
1–12 months	42	76.36	27.51	5.56	62.42
13–24 months	9	16.36	37.75	17.1	67.6
Not stated	1	1.81	....	....	....
Patients living					
1–12 months	1	1.81	10.0	8.0	65.0
13–24 months	2	3.63	27.0	18.5	63.5

until recent years it has not been appreciated how frequently metastasis occurs, especially in the bones.

TABLE IV

METASTASIS REVEALED BY ROENTGENOGRAMS: 228 PATIENTS

	Examined	*Metastasis*	*Per Cent*	*Age*
Total.....	228	69	30.26	63.3
Pelvis.....	153	46	30.7	62.76
Spine.....	154	40	25.97	62.5
Lungs.....	140	8	6.4	65.5
Ribs.....	141	8	5.0	66.0
Femurs.....	122	7	5.7	63.4

DISCUSSION OF TABLE IV

Of the 646 patients only 228 (35.29 per cent) were examined roentgenographically for metastasis, and of this number 163 (71 per cent) were examined during the past three years. In the early cases, the roentgen ray was not as easily available as it is now, and the impression seemed to prevail that it was sufficient if the chest was examined for metastasis. This accounts for the fact that until within the last year more roentgenograms were made of the chest than of the spine and pelvis. Data compiled previous to the last year showed that the pelvis was involved in 37.5 per cent of cases, the lumbar spine in 35.8 per cent, and the lungs in 3 per cent; the latter were never involved unless metastasis was demonstrable elsewhere. It is significant that these percentages which were compiled from a series of only 135 cases, still hold true in this larger series of 228 cases in which the pelvic bones were involved in 30 per cent, the spine in 25.97 per cent, and the lungs in but 6 per cent.

The data in Table IV shows that if the spine, the pelvis, and the femurs are examined by the roentgen ray routinely in all cases of diseased prostates suspected of being malignant, a negligible number of cases of metastasis will remain undiscovered. It does not seem necessary to examine the chest as a routine procedure since metastasis to the lungs alone probably never occurs in these cases. It would seem conservative to state that 30.26 per cent, or practically one-third of all patients with carcinoma of the prostate, will be found to have metastasis to the bones, and the overwhelming percentages will be found in the pelvis, the spine, and the femurs. The average ages of the patients also bear evidence of the lateness of metastasis to the lungs. The average age in the entire series of 646 patients is 64.6 years; the average age of patients with metastasis to the pelvis and spine is from one to two years less; and of patients with metastasis to the lungs and ribs from one to two years more, demonstrating still further that metastasis does not occur in the chest until after it occurs in the spine and pelvis.

Stewart believes that in the majority of cases of metastasis to the bones the primary growth can be diagnosed by the roentgenographic appearance of the metastasis. He

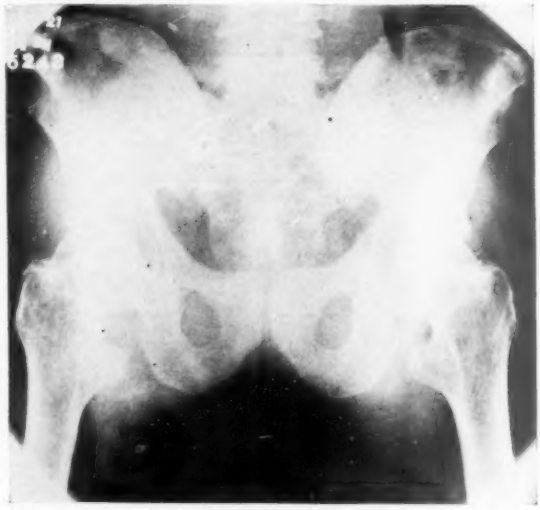


FIG. 1 (345,243). Metastasis to the pelvis, sacrum and lumbar spine.

quotes from Phemister as follows: "Metastasis in bony structure following a primary carcinoma assumes the characteristics of the original growth; if the stroma predominates in the primary lesion, we are sure to have a condensing or osteoplastic form of metastasis; if the primary cancer were of a medullary form, we would have a secondary rarifying or osteoclastic process."

Stewart calls attention to the fact that in carcinoma of the prostate the stroma predominates, and a condensing form of secondary lesion should occur (Figs. 1, 2, 3, 4, 5 and 6). This is in keeping with von Recklinghausen's findings and applies to the majority of cases, but as may be seen in Figures 7, 8 and 9 osteoclastic metastasis also occurs and although it occurs infre-

quently there is little chance of error in the diagnosis. The osteoclastic type of metastasis is found in the majority of cases. The close similarity of this type to Paget's

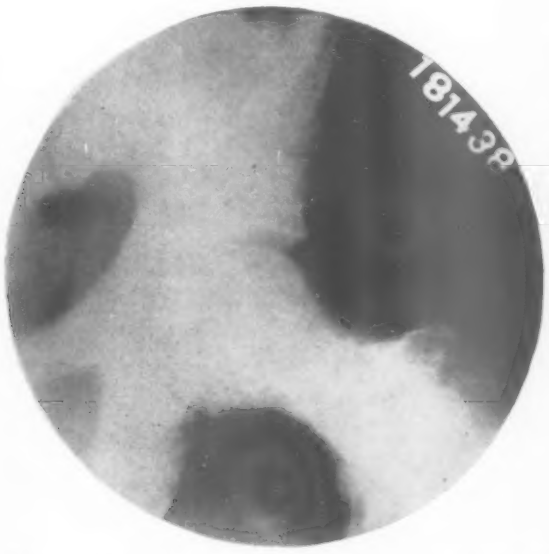


FIG. 2 (181,438). A condensing form of secondary lesion with extensive osteoclastic metastasis in the femur and pelvis.

FIG. 3 (181,438). Extensive metastasis to the sacrum, lumbar spine and ilia.

disease has recently been emphasized by Carman and Carrick; this may be readily appreciated by an examination of Figures 10, 11, 12, 13, 14, 15, 16 and 17, in which the two conditions in similar locations are illustrated for comparison.

FIG. 4 (201,980). Metastasis to the lumbar spine, pelvis and sacrum.

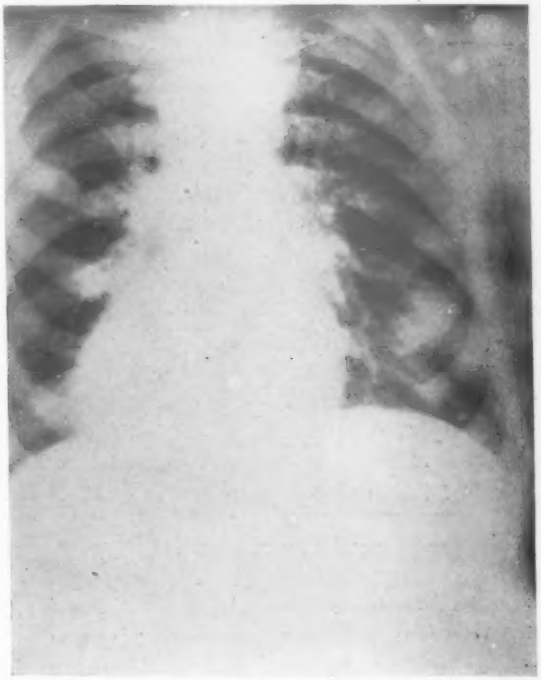


FIG. 5 (194,448). Area of metastasis to the right lung.

In cases in which the prostatic enlargement is unquestionably malignant, the possibility of error in diagnosis is negligible.

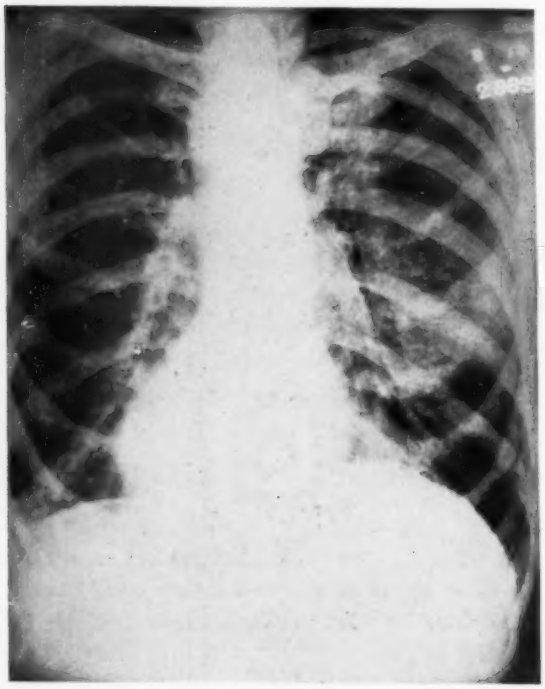


FIG. 6 (288,379). Metastasis to the ribs.

However, there is a less frequent form of prostatic malignancy in which the uniform enlargement was without any of the irreg-

FIG. 7 (289,964). Destruction of right ischium, as the result of a metastatic growth in which the osteoclastic tendency predominates.

ularities of contour presented by the common type of carcinomatous gland and without the characteristic stony hard areas. This type of malignant gland resembles true inflammatory hypertrophy and often is confused with it, but it differs

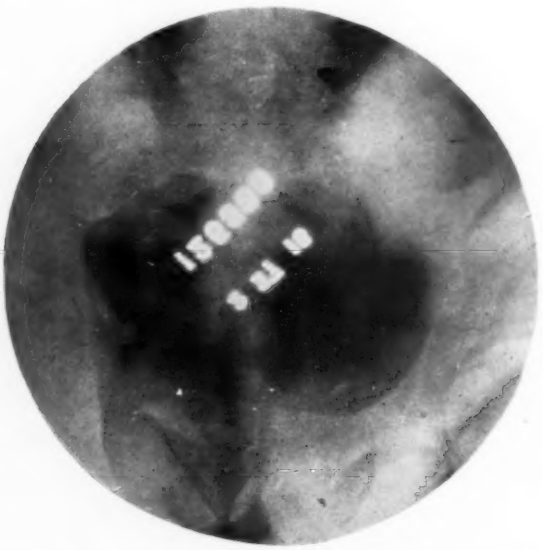


FIG. 8 (125,337). Osteoclastic metastasis; the right pelvic bone and ischium destroyed.

FIG. 9 (311,469). Destruction of the right ischium, the result of a metastatic growth in which the osteoclastic tendency predominates.

in that the resilience is lost, while in inflammatory disease it always remains. Such glands never reach a size that cannot be

outlined by the examining finger, because they are composed of cells which exhibit no tendency to acinus formation but are scattered throughout a somewhat increased fibrous stroma and metastasize so early that death results before the gland becomes greatly enlarged. A section from this type of gland (Fig. 18), illustrates its close resemblance to scirrhous carcinoma of the breast. The reason for early metastasis is shown by the cells infiltrating a somewhat increased fibrous stroma and exhibiting no tendency to acinus formation. In such cases the rheumatic pains of metastasis, or the paraplegia of spinal involvement, are frequently the first symptoms, and the patients often die before any urinary symptoms occur to call attention to the prostate as the primary focus of extensive metastasis to the bones. Or, if the prostate is examined its slight enlargement and its atypical feel of carcinoma make a diagnosis of malignancy doubtful. If it cannot be determined that the prostate is malignant, and there are no urinary symptoms, the condition may be Paget's disease. The mistake has been made of diagnosing as malignant an old firm inflammatory prostate because the roentgenograms revealed what was supposed to be metastasis to the bones. In Paget's disease the bodies of the lumbar vertebrae are flattened and widened, while

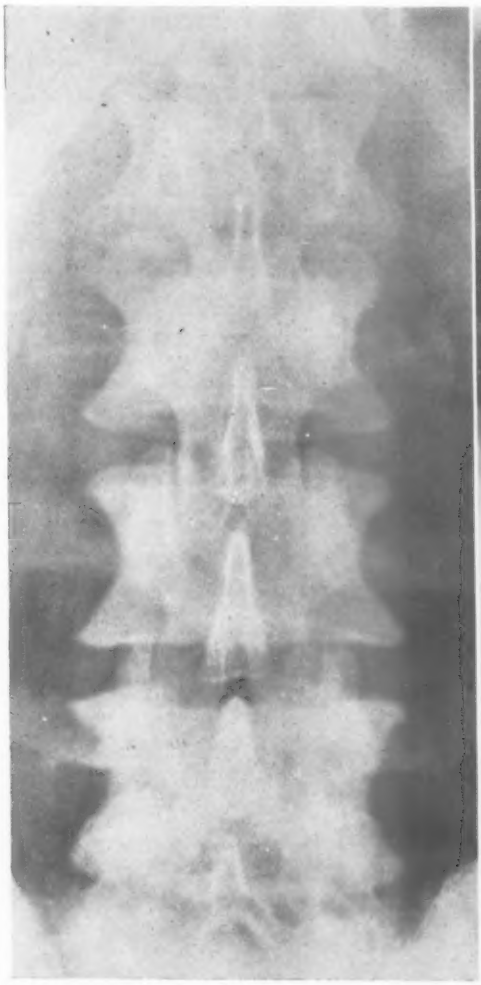


FIG. 10 (345,243). Metastasis to the spine from carcinoma of the prostate.

FIG. 11 (343,042). The spine in a case of Paget's disease. Pronounced flattening and deformity of the vertebræ (Fig. 10).

FIG. 12 (324,762). Lumbosacral region in a case of carcinoma of the prostate with metastasis. Note similarity of condition with that shown in Figure 13.

FIG. 13 (318,460). Lumbosacral region in a case of Paget's disease. Note similarity of condition with that in Figure 12.

in malignant conditions there is little if any change in the shape of the vertebrae. However, as Carman and Carrick point out, there is one means of making the diagnosis certain: "If the skull shows the pathognomonic changes of Paget's disease, that is,

FIG. 14 (334,035). Metastasis to the pelvis from carcinoma of the prostate.

thickening and density of the inner table and the finely porous outer table with scattered nodules of bone over the vault, the diagnosis of Paget's disease is certain." Therefore, in all cases of apparent metastasis to the bones in which the prostate is suspected of being malignant, roentgenograms should be made of the head before a

FIG. 15 (302,252). The pelvis in a case of Paget's disease.

positive diagnosis is made. From the foregoing, it is evident that if the untreated cases are used as a basis of comparison of results obtained from radium therapy, the cases in which metastasis was found must be excluded (Table v).

DISCUSSION OF TABLE V

Since the patients who received radium treatment were treated immediately following the diagnosis, it seems logical to consider the length of life of the untreated patients following the diagnosis, to be comparable with the length of life of those who received treatment. This period in the untreated patients is 12.98 months, or thirteen months.

FIG. 16 (212,968). Metastasis to the femur from a case of carcinoma of the prostate.

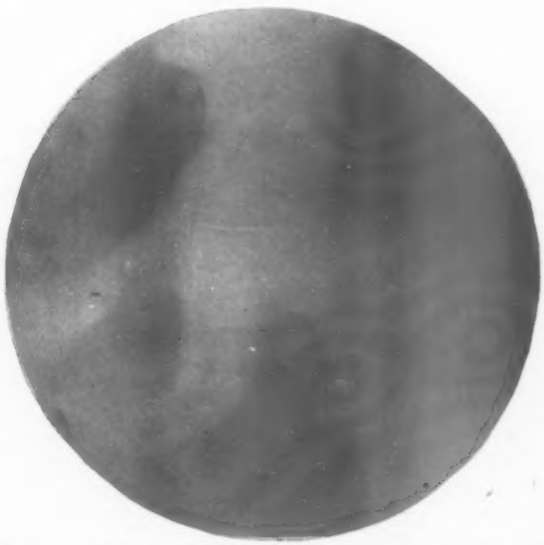


FIG. 17 (289,230). The femur in a case of Paget's disease, showing similarity to Figure 16.

In order not to base such an extensive statistical study on one period of time the duration of the disease in each case from the first symptom to the time of death has been obtained. These data are subject to a certain degree of error, since carcinoma may develop on benign hypertrophy and the first symptoms may be due to the benign hypertrophy rather than to the malignancy. However the group of patients with atypical carcinoma of the prostate who do not have symptoms until the disease is well advanced, offsets this error and it seems accurate to consider the average length of the disease to be 36.61 months or three years, and the average duration of life after diagnosis, thirteen months. These periods are used as the basis for judging the results of the various methods of radium application. Besides these averages there is recorded for comparison in each group the number of patients that died in each year after treatment, for it is evident that if averages alone are used as the basis of comparison, the few successfully treated patients become merged in the general average and their importance as a basis of comparison

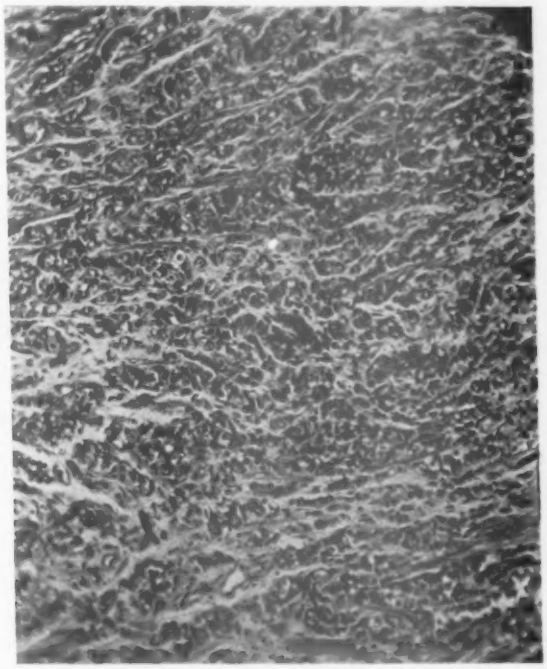


FIG. 18 (20,348). Highly malignant adenocarcinoma. This type causes only slight local enlargement but metastasis early, often resulting in the metastasis being confused with Paget's disease, because of slight prostatic enlargement.

is lost. Also, in considering the length of the disease, it must be kept in mind that the patient is never considered cured, and if the length of the disease has been extended by any method of treatment

urethral burns. Cross-firing was then attempted by applying half the dose through the rectum. The mucosa of the rectum proved to be even more susceptible to burns than that of the urethra and great

TABLE V

TWO HUNDRED THIRTY-FIVE PATIENTS WITHOUT TREATMENT AND WITHOUT METASTASIS

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Length of Life After Examination, Months*	*Average Age, Years*
Heard from	176	.....	36.61	12.98	65.25
Dead	163	92.6	34.08	10.13	65.09
Living	13	7.3	70.5	44.61	67.23
Patients who lived					
1– 12 months	107	60.79	29.72	4.76	65.1
13– 24 months	23	13.1	43.09	17.69	64.21
25– 36 months	8	4.5	46.28	26.37	67.5
37– 48 months	3	1.7	75.0	44.3	67.0
49– 60 months	2	1.13	68.0	52.0	68.5
73– 84 months	1	0.56	.....	78.0	69.0
Not stated	19	10.79	.....	.....	.....
Patients living					
1– 12 months	3	1.7	10.0	9.66	67.0
13– 24 months	2	1.13	38.5	21.0	74.0
25– 36 months	1	0.56	149.0	29.0	70.0
37– 48 months	2	1.13	120.0	47.0	68.5
49– 60 months	1	0.56	49.0	49.0	66.0
61– 72 months	2	1.13	73.0	70.0	63.5
73– 84 months	1	0.56	.....	79.0	63.0
108–120 months	1	0.56	144.0	118.0	62.0

TABLE VI

FORTY PATIENTS TREATED BY RADIUM THROUGH THE RECTUM AND THE URETHRA

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Duration of Treatment, Months*	*Urethra*	*Rectum*	*Milligram Hours*	*Average Length of Life After Radium Treatment, Months*	*Average Age, Years*
Heard from	37	.....	44.09	2.36	250.0	1537.91	1585.2	18.27	66.2
Dead	33	89.18	42.2	2.5	225.0	1581.9	1622.8	15.31	62.6
Living	4	10.81	62.3	1.2	400.0	1175.0	1275.25	42.0	70.75
Patients who lived									
1–12 months	17	45.94	33.4	1.23	220.0	1162.6	1286.1	6.64	63.58
13–24 months	7	18.91	39.0	2.68	.....	1503.4	1503.4	17.0	66.0
25–36 months	6	16.21	57.5	5.55	250.0	2269.0	2310.6	28.	69.60
37–48 months	2	5.4	93.0	4.7	.....	3250.0	3250.0	43.0	67.5
Not stated	1	2.7	.....	.....	.....	.....	.....	.....	.....
Patients living									
37–48 months	4	10.81	62.3	1.2	400.0	1175.0	1275.25	42.0	70.75

beyond the three-year-average period for untreated cases, it is considered favorable.

TECHNIQUE OF RADIUM TREATMENT

In the first cases of carcinoma of the prostate treated by radium the radium was introduced through the urethra. In well-advanced cases, however, the necessity of applying large doses resulted in

care was necessary in screening and in regulating the duration of the exposure. An applicator similar to the one described by Young was used, the rectal mucosa being protected by brass and lead screens except at the point of exposure. The treatments were given every third or fourth day until the desired dosage was obtained. Forty patients, including seven in which

both urethral and rectal applications were given were treated in this manner. Information has been obtained concerning thirty-seven (92.5 per cent) of these (Table VI).

DISCUSSION OF TABLE VI

The technique employed in the treatment of these forty patients had several distinct advantages, the most important of which is the great amount of radiation reaching the periphery of the growth in which location the greatest cell activity occurs. The application is easily accomplished and a comparatively small amount of radium is required, a standard of 50 mg. or 100 mg. tube being sufficient. The applicator is of simple design and adapted to general use. The chief drawbacks were the irritability of the rectal mucosa which frequently did not permit the amount of radiation indicated even with the greatest care in screening. Although the area of greatest cell activity receives the greatest amount of radiation, yet even in moderately enlarged glands, comparatively small amounts of radiation reach the center of the growth where cell activity, although not so active, nevertheless takes place. Therefore, unless all portions of the growth receive sufficient dosage to impair this activity, satisfactory results cannot be expected.

With these disadvantages in mind, it is interesting to observe the clinical results recorded in Table VI. In these the average length of disease was forty-four months, eight months longer than the average of untreated patients. The average length of life after treatment is eighteen months, five months longer than could be expected if no treatment had been given. While these data are evidence of the inhibitory influence of radium on the disease, this inhibitory influence is not sufficient to commend the treatment. For merely to delay the inevitable for a short period, rather than appreciably to arrest the disease process, is a result which is not to be sought when death is often more longed for than dreaded.

Statistics of the average length of life are valuable, but they must not be taken as final since they may obscure several cases in which the results indicate marked advantages to such treatment. For example, six patients (16.21 per cent) lived more than three years; four are still alive, while only seven (3 per cent) of those not treated are alive three years after examination. This is encouraging when the hopelessness of the condition is considered, but not encouraging enough to warrant urging the patient to take the treatment with considerable expense and inconvenience. Marion, realizing the difficulty of properly radiating all parts of the gland by this method, and probably being cognizant of the clinical results, inserted a trochar directly into the substance of the gland, and by means of the obturator placed the radium tube directly into the tissue. The tube was withdrawn by means of an attached string after the required application.

Barringer described a similar but far superior method. He placed the radium in a hollow needle, and guided by a finger in the rectum, inserted it directly into the gland through the perineum. This method seemed so superior to all others that the earlier procedures were for the time abandoned. The cases so treated are reported in Table VII.

DISCUSSION OF TABLE VII

The thirty-five patients whose cases are reported in Table VII were treated by means of needles alone. The average length of the disease in the twenty patients heard from in this group is prolonged approximately four months beyond the normal three years. The average length of life, however, after such treatment, is two months less than that of those not treated. The dosage in this series averaged 1,200 mg. hours, approximately 455 mg. hours less than in the group in Table VI. The decreased dosage is not a sufficient reason to explain the poorer results obtained, results which are still more strikingly brought out when the individual cases are examined. Ten (50 per cent) of the patients died the first year after treatment, seven of the remaining ten died the second year. The date of one patient's death is not given, and the two living patients have not yet lived two years after treatment. Regrettable as

TABLE VII

THIRTY-FIVE PATIENTS TREATED BY NEEDLES

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Duration of Treatment, Months*	*Needles*	*Milligram Hours*	*Average Length of Life After Radium Treatment, Months*	*Average Age, Years*
Heard from	20	....	39.68	1.5	1201.9	1201.9	11.0	63.95
Dead	18	90.0	41.05	1.75	1250.94	1250.94	10.47	63.5
Living	2	10.0	28.0	1.0	760.0	760.0	15.0	68.0
Patients who lived								
1–12 months	10	50.0	37.6	1.17	1246.1	1246.1	5.4	61.3
13–24 months	7	35.0	29.6	2.76	1657.6	1657.6	17.0	65.4
Not stated	1	5.0	.....	....	.....	.....	.....	.....
Patients living								
1–12 months	1	5.0	29.0	1 da.	850.0	850.0	7.0	68.0
13–24 months	1	5.0	27.0	1 da.	671.0	671.0	24.0	68.0

these results may appear they are nevertheless valuable, for they demonstrate clearly that neglect to radiate the periphery of the growth, where the greatest cell activity occurs, will result in failure. They also show that if radium is placed within the gland tissue, the gamma rays do not penetrate sufficiently to reach the peripheral cells, or, if they do, are too greatly diffused to be effective. It was evident, therefore, that the amount of radium should be increased, and an attempt was made to give, if possible, between 3,000 and 4,000 mg. hours, 2,000 by needles, the remaining 1,000 by rectum and urethra.

In giving this larger dosage a modification of the old applicators was found useful. The great majority of such apparatus consists of an arm attached to the examining table which holds in place a metal tube containing the radium. It was found, however, that a piece of sheet lead cut in the shape of a spoon (Fig. 19) is the most satisfactory applicator. The small metal container holding the radium is placed in the bowl and the lead is bent over three sides of it. Over this a hard rubber tube is slipped to filter the beta rays on the exposed side; thus the rectal mucosa is screened by lead except the portion directly over the prostatic area; there the irritating rays are filtered out by the hard rubber tube. When the applicator is inserted and placed in the desired position, the open side of the bowl is placed next to the prostate, the handle is bent at right angles and attached to the thighs or buttocks by surgeons plaster. This method allows the patient to move around freely while recumbent and while the applicator is still in position, instead of subjecting him to the discomfort of remaining in one position on an examining table to which a rigid mechanical arm is attached. In making the urethral applications, screened only by the standard silver container, nothing has proved so

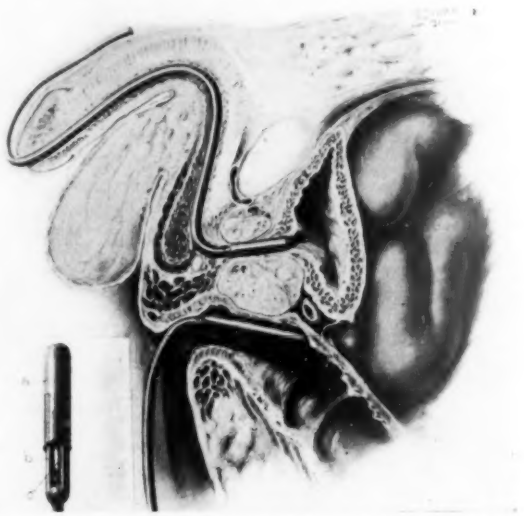


FIG. 19. Cross-section through the pelvis. Rectal and urethral applicators in place. Inset: rectal applicator; (a) hard rubber sheath, (b) lead spoon, and (c) standard radium tube.

useful as a stick of soft solder, the end of which is threaded so that the container may be directly screwed on. The stick of solder can be bent to adapt it to the various prostatic curves, and is easily kept in position (Fig. 19).

The results of the increase in dosage and more thorough radiation of the

prostate are difficult to interpret, because this group of patients was treated more recently than the others. A casual examination of Table VIII might lead to the conclusion that the change in treatment had not resulted in improvement.

DISCUSSION OF TABLE VIII

Obviously in dealing with recent cases, the duration of the disease to the time of death and the length of life following treatment do not represent completed averages. Judgment must, therefore, be based on other sources. In the group of patients treated by rectum and by urethra, 45.94 per cent died during the first year after treatment; in the group treated by needles alone, 50 per cent; in the untreated group, 60.79 per cent; and yet with the combined treatment only 28.78 per cent died the first year. Although sufficient time has not elapsed to give a higher percentage among the living it should be noted that the length of life following treatment already exceeds the average for the patients not treated and that the living represent 54.54 per cent of the patients heard from. The results argue well for the change in treatment.

TABLE VIII

NINETY-SEVEN PATIENTS TREATED BY NEEDLES AND BY URETHRA AND RECTUM

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Duration of Treatment, Months*	*Needles*	*Urethra*	*Rectum*	*Milligram Hours*	*Average Length of Life After Radium Treatment, Months*	*Average Age, Years*
Heard from	66	.....	34.37	6.9	1655.9	304.95	437.47	2240.72	12.76	64.33
Dead	30	45.45	26.96	4.32	1144.7	352.88	423.55	1625.46	11.28	64.9
Living	36	54.54	39.88	7.56	2081.91	291.03	448.69	2753.44	13.91	63.86
Patients who lived										
1–12 months	19	28.78	26.52	2.37	1242.68	374.33	319.61	1609.15	6.84	65.57
13–24 months	8	12.12	32.42	6.4	777.5	.....	402.5	1180.0	18.5	62.37
37–48 months	1	1.51	.....	3.2	2062.0	550.0	2870.0	5482.0	38.0	55.0
Not stated	2	3.03	.....	.....	.....	.....	.....	.....	.....	.....
Patients living										
1–12 months	19	28.78	40.94	4.6	1627.0	274.22	471.0	2410.42	8.94	64.21
13–24 months	15	22.72	38.07	8.49	2593.73	330.5	524.26	3255.73	17.89	63.6
25–36 months	1	1.51	36.0	1.9	2210.0	120.0	120.0	2450.0	26.0	62.0
37–48 months	1	1.51	49.0	2.45	1920.0	.....	120.0	2040.0	37.0	63.0

TABLE IX

ONE HUNDRED SEVENTY-FIVE PATIENTS TREATED BY RADIUM ONLY

	Patients	*Per Cent*	*Average Duration of Disease, Months*	*Average Duration of Treatment, Months*	*Needles*	*Urethra*	*Rectum*	*Millligram Hours*	*Average Length of Life After Radium Treatment, Months*	*Average Age, Years*
Heard from	126	.....	38.58	4.27	1526.65	296.76	836.65	1866.49	14.17	64.88
Dead	84	66.6	37.3	2.89	1183.79	301.73	1040.09	1541.16	12.83	64.96
Living	42	33.3	40.97	6.95	1959.73	294.43	521.3	2493.9	16.66	64.71
Patients who lived										
1–12 months	46	36.5	31.44	1.69	1243.86	159.33	729.94	1410.86	6.45	63.91
13–24 months	22	17.46	33.9	4.14	1154.71	.....	916.26	1424.28	17.57	64.5
25–36 months	6	4.76	57.5	5.55	.....	250.00	2269.0	2310.66	28.6	69.66
37–48 months	3	2.38	93.0	13.8	2062.0	550.0	3123.3	3994.0	41.3	63.3
Not stated	7	5.55	.....	.....	.....	.....	.....	.....	.....	.....
Patients living										
1–12 months	20	15.87	38.9	4.6	1588.15	259.78	471.0	2332.4	8.85	64.4
13–24 months	16	11.76	37.33	7.97	2473.55	330.5	524.26	3094.18	18.25	63.87
25–36 months	1	0.79	36.0	19.0	2210.0	120.0	120.0	2450.0	26.0	62.0
37–48 months	5	3.96	59.0	5.9	660.0	.....	964.0	1428.0	41.0	69.2

DISCUSSION OF TABLE IX

In Table IX are summarized the results of all forms of radium treatment.

Of the 126 patients heard from, the average duration of the disease from onset to death is 38.58 months, a little longer than may be expected if the malignancy is allowed to take its course. The average dosage was 1866.49 mg. hours and the length

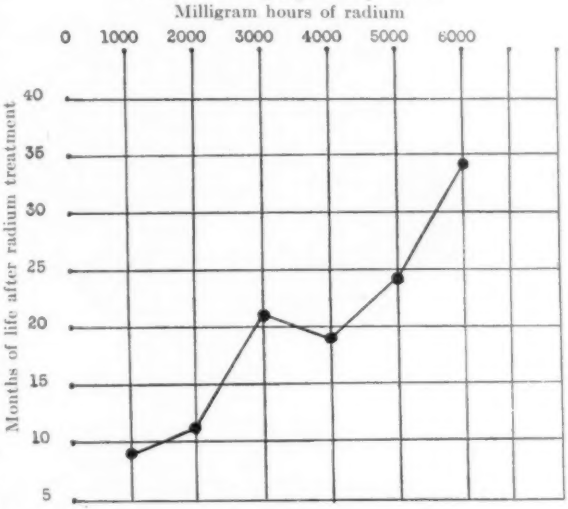
of life following treatment, 14.17 months, only slightly longer than the average length of life of patients not treated.

A comparison of the results followng radium treatment with those obtained by surgery demonstrates the superiority of the latter, for in the surgical group the disease extended 50 per cent longer, reaching on the average, 62.36 months, and the length of postoperative life averaged ten months longer. At the end of two years 29.16 per cent of the patients treated surgically are alive and only 11.9 per cent of those treated with radium are alive. These comparisons are not wholly just, for the patients operated on represent a picked group and in 27 per cent of them, the cancer was only discovered at operation, while the patients treated by radium were unselected and the disease was advanced sufficiently to make a diagnosis. However, by examining the results from an entirely different view point, namely, with reference to the size of dosages, the percentages are more encouraging. In the three groups of patients studied, the length of life after radium treatment (completed cases) appears directly proportional to the dosage. That is, the average dosage for patients who lived two years was greater than for patients who lived one year, and less than for those who lived three years. That this was not accidental is borne out by grouping the patients according to the amount of radium they received instead of according to the years they have lived. The data are more accurate when taken from the completed cases, the patients who have died, for the number living includes patients who are alive because of mistaken diagnosis.

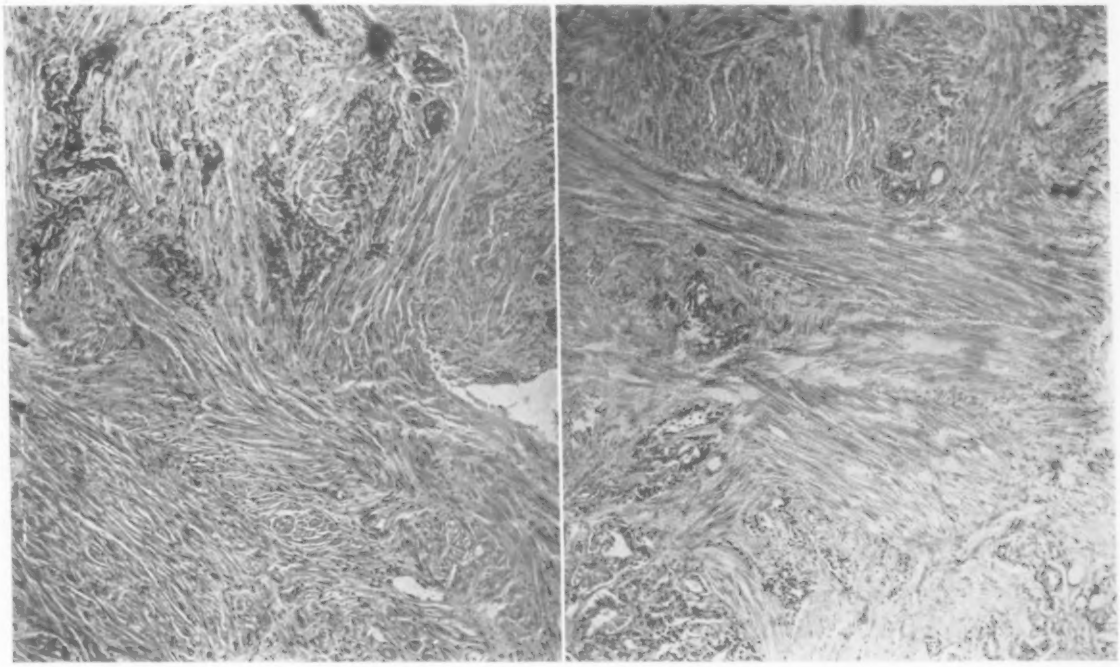
DISCUSSION OF TABLE X

The data in Table x might be interpreted as meaning that because the patient lived longer, he had more opportunity to receive radium, rather than that he lived because he received it. That this is fallacious is apparent from the duration of treatment, which averages between six months and one year. This relationship between dosage and the prolongation of life is undoubtedly due to the fact that a more thorough radiation of the malignant growth had taken place and cell activity had been largely destroyed. In four of the twenty-two patients who received both radium and surgical treatment, the prostatectomy followed a thorough course of radium treatment, and was done to relieve the patients of urinary obstruction, not with the idea of removing the growth. Tissue in these cases yielded sections in which the end-results of radium are clearly manifest, microscopically.

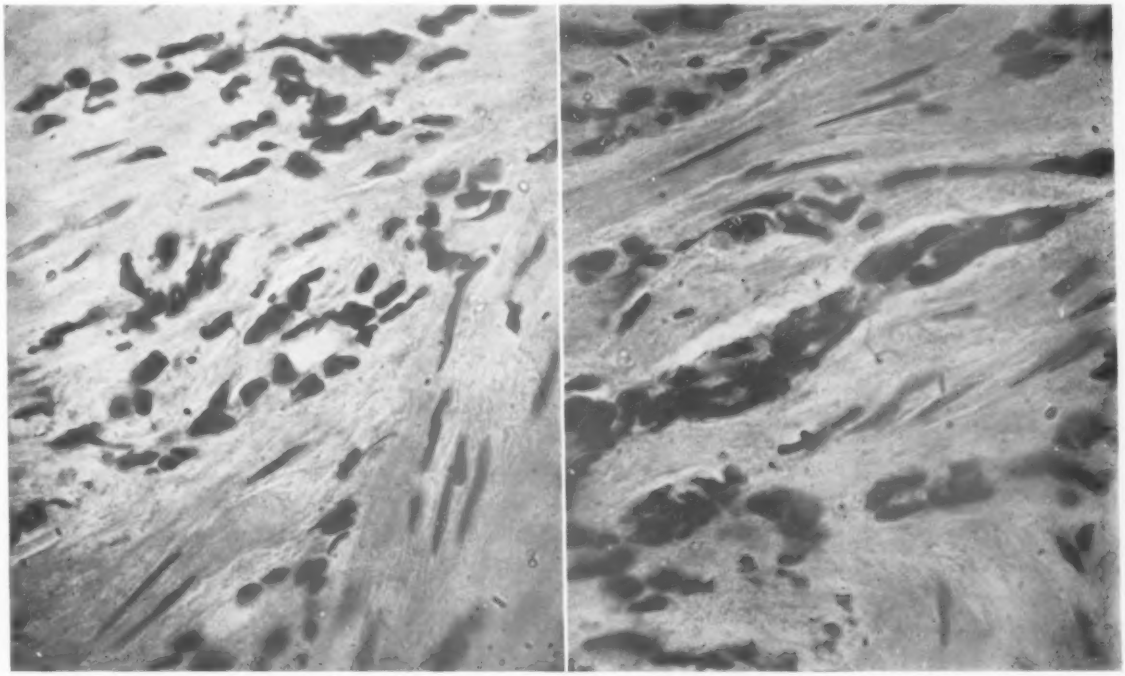
TABLE X. Eighty-four patients



In Case 219,826 (Figs. 20 and 21) 1,742 mg. hours of radium were given, the last treatment three months before the removal of the gland. Moderate hyaline degeneration is shown throughout the section and a marked proliferation of fibrous tissue surrounds and compresses the remaining cancer cells in interlacing fibrous bands. These malignant cells are atypical in appearance, being pressed and squeezed in distorted shapes by an ever-increasing proliferation of connective-tissue cells (Figs. 22 and 23). The reproductive function of the malignant cells is undoubtedly impaired and if all malignant tissue can be thus affected, complete cessation of the process must occur. The immediate results of radium treatment by needles a few days before death are shown in Figure 24. The necrotic and discolored appearance in the center of the photograph gives a clear idea of the limited extent of the radiation. Figure 25 is a photomicrograph of an area beyond the influence of the



FIGS. 20 and 21 (219,826). Adenocarcinoma of the prostate after it had been exposed to 1,742 mg. hours of radium. The last treatment had been given three months before.



FIGS. 22 and 23 (219,826). Adenocarcinoma of the prostate after it had been exposed to 1,740 mg. hours of radium. The last treatment was given three months before. The distorted and flattened cells indicate the extreme pressure exerted by the proliferation of fibrous tissue cells. In places, this compression is so marked that only the remains of the cancer cells are seen as a few deeply staining nuclei fragments.

radium treatment. Typical cancer cells have replaced the normal glandular tissue. Their clear outline and marked staining qualities, and the occasional mitotic figure show their viability and gives impressive evidence of malignancy. Figures 26 and 27 represent other sections from the same gland but are taken closer to the area affected by the radium. Many of the cells show evidence of rapid degeneration, and

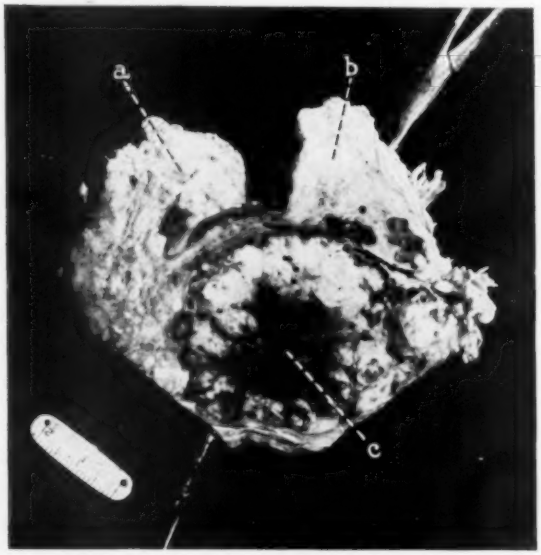


FIG. 24 (332,467). Adenocarcinoma of the prostate treated thirty-two days before death with 700 mg. hours of radium. A limited area of the carcinoma was affected and a localized necrosis resulted. (a) and (b), lateral lobes, and (c) point of radium application. Note limited area affected by large dosage.

there is a loss of the definite cell outlines of the viable cancer cells shown in Figure 25. These cells take the stain poorly and fragments of destroyed cells are seen throughout the section. The entire picture is that of cellular destruction and is in sharp contrast with Figure 25.

The microscopic findings, and the marked softening and shrinking of the gland, often found clinically following radium treatment, are clear evidence that if the entire growth can be reached by the radium rays, satisfactory results will follow. Clinical findings, however, demonstrate that except in occasional cases satisfactory results have not been obtained.

The question arises, should radium treatment in cancer of the prostate be abandoned? Undoubtedly it should be abandoned in a great many instances; after the growth has extended beyond the capsule the lymphatics are probably always involved, and the duration of the patient's life will not be altered, even if the local and original growth is softened by the treatment. Apparently much more good can be accomplished by proper care of the urinary retention by means of suprapubic drainage or daily catheterization than will be accom-

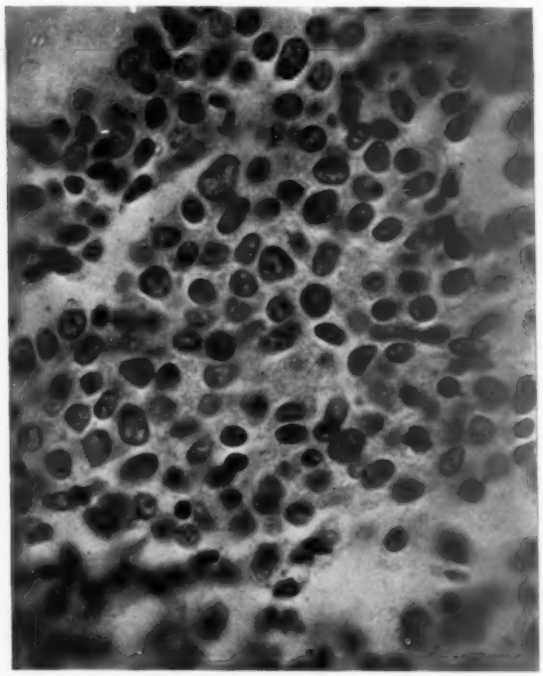
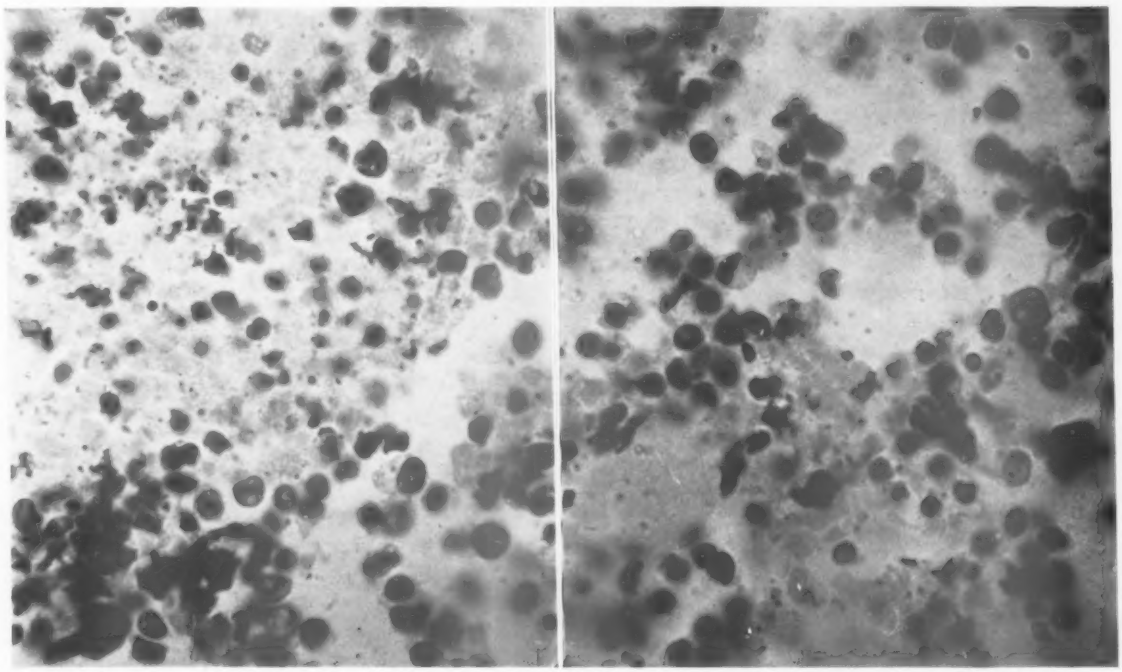


FIG. 25 (332,467). Adenocarcinoma of the prostate showing well formed and highly malignant cells unaffected by radium exposures given in other portions of the gland.

plished by treating the gland with radium. In a few cases a subsidence of the urinary obstruction and a marked reduction in the amount of residual urine will result but as a rule the amount of residual urine remains unchanged and occasionally the obstruction is made greater. In the early cases, in which the malignancy is still confined within the capsule, radium should be used, but its application must be modified if better results are to be expected even in this limited group of cases.

As is apparent in Figure 24, the changes due to radium, namely, cell destruction and necrosis, are confined to a limited area. Sections of other portions of the

gland (Fig. 25) show no evidence of radiation. That such necrosis occurs where radium is applied directly into the tissues has been clearly demonstrated by Bagg, who shows that the area affected by 1 mc. tube is approximately 1 cm., that necrosis occurs for about 1 or 2 mm. but beyond this point the malignant cells are killed for approximately 0.05 cm. Increasing the dosage from 1 to 5 mc. does not correspondingly increase the area of affected tissue which remains approximately 1 cm. in diameter as before, but it does increase the area of necrosis around the emanation tubes, a result to be avoided since it permits nonseptic toxic absorption and is responsible for the so-termed radium reactions.



FIGS. 26 and 27 (332,467). Recently radiated area of adenocarcinoma of the prostate, showing the effect of radium rays on the individual malignant cells. Marked disintegration has resulted as shown by the loss of cell outline, poor staining qualities, and masses of cell fragments.

The poor results in the past have evidently been due to overradiation of one portion of the gland, while other portions received too little. The poor clinical results are particularly apparent in the cases in which needles alone were used, owing undoubtedly to the lack of radiation to the periphery of the growth, to which the gamma rays did not penetrate, or, if they did, were scattered and had little effect.

It is evident, therefore, that to obtain better results, a greater area of the gland must be radiated with smaller doses. In the past, this has been excessively difficult and nearly impossible, for to insert needles more than once at a single treatment causes too great pain. An attempt was made to obviate this difficulty by inserting multiple tubes, as described by Bagg, but their exact position was uncertain and it was difficult accurately to estimate the position of the first tubes when the next one was applied. It is better not to leave emanation tubes in this deep lying gland, for if complications, such as sloughing, occur, nature may attempt to throw off the foreign bodies rather than to encyst them. For this reason it seems that if radium needles could be used more thoroughly, they would be preferable.

The possibility of now using radium needles more satisfactorily has recently been greatly favored by a method of inserting the radium needles under sacral anesthesia, as described by Scholl. He states, "Nerve blocking in no part of the body offers more satisfactory or successful results than sacral anesthesia. It is not new,

nor is its application to this use unusual, but its almost complete neglect indicates that its good results are not generally recognized." The absolute anesthesia obtained throughout the perineum and prostate, and the complete relaxation of the

FIG. 28. Cross-section of pelvis. Radium needles inserted into the prostate.

rectal sphincter make it ideal for placing needles within the prostate gland (Fig. 28), since the exact location desired can be reached without pain to the patient. The relaxed rectal sphincter makes careful palpation of the growth possible.

The anesthetic is administered with the patient on his abdomen. After sterilizing the sacral region with iodine, a 6 cm. needle with stylet is introduced through the sacral hiatus at the lower end of the sacrum, into the sacral canal (Fig. 29). About 30 c.c. of a 2 per cent solution of novocaine is injected while the needle is being slowly withdrawn. After this, the patient is kept in the sitting position for from ten to fifteen minutes, while the solution diffuses through the sacral nerve sheaths. This diffusibility is greatly increased if sodium carbonate is added to the novocain. The formula is as follows: Novocain 0.6 gm., sodium carbonate 0.15 gm., sodium chloride 0.1 gm. added to 30 c.c. of freshly boiled distilled water gives a sterile 2 per cent solution of novocain in normal salt solution.

The anesthesia is complete and commences in about four minutes at the anosacral area (Fig. 30), the exact location at which the needles are inserted (Fig. 31). The anesthesia may be repeated at any time and the position of the needles in the gland changed, so that new areas are radiated. After the second injection the anesthesia is much more profound and

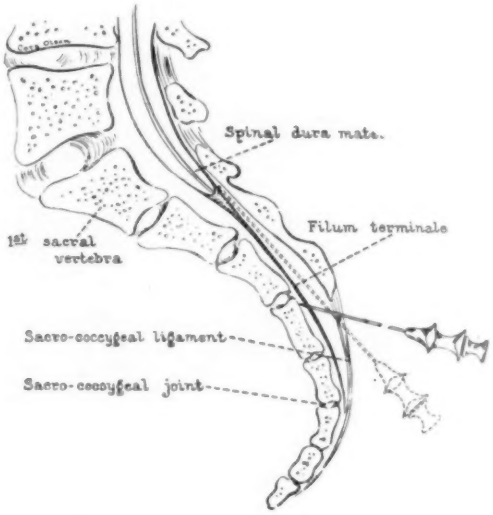


FIG. 29. Cross-section of sacrum. Sacral canal and point of insertion of needle. The novocain is given outside the spinal dura mater.

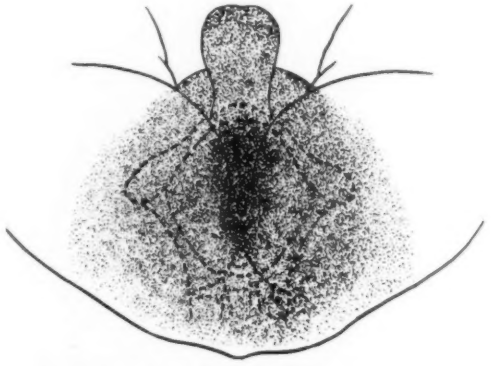


FIG. 30. Point of initial anesthesia in the perineum, which corresponds with point of needle insertion.

lasts from five to eight hours, permitting a third shifting of the radium-containing needles and giving the patient a period of rest and freedom from pain during the procedure. This anesthetic has been used in more than 100 instances with complete satisfaction. Patients are no longer reluctant to take a second treatment and the increased ease with which the needles are applied, owing to the complete relaxation of the rectal sphincter, adds greatly to the

exactitude of the procedure, and before the completion of the treatment all parts of the gland will have been radiated.

The entire treatment is given within a few days and the patient need not return for subsequent treatments. It is scarcely necessary to call attention to the advantages gained by this method. There is no opportunity for growth of the untreated portions of the gland between treatments. Necrosis does not occur, since fibrous tissue, which greatly reduces the blood supply, has not formed as the result of previous radium treatment.

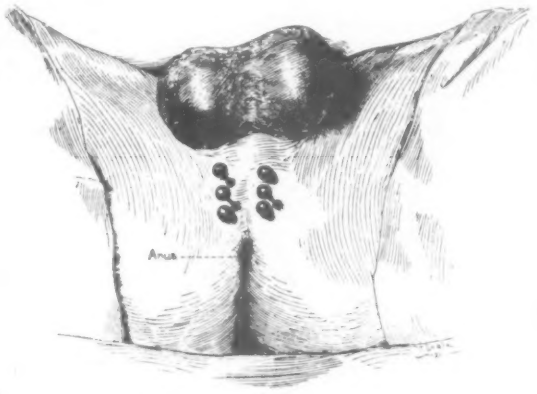


FIG. 31. Six radium needles inserted in the perineum.

SUMMARY

1. The average duration of cancer of the prostate, if untreated, is approximately three years.

2. Roentgenograms show that metastasis to the bone occurs in about one-third of the cases of cancer of the prostate.

3. Metastasis from atypical carcinoma of the prostate, in which the cells, because of their tendency to early metastasis, produce only slight local enlargement, may be frequently mistaken for Paget's disease.

4. The clinical study of these cases demonstrates that in order to treat successfully cancer of the prostate with radium it is necessary to use in the aggregate large doses (3,000 to 4,000 mg. hours), exposing all parts of the gland to comparatively small doses.

5. It is demonstrated that the increased duration of life following radium treatment in cases of cancer of the prostate is in direct proportion to the amount of radium radiation applied.

6. No one method of application radiates all portions of the gland.

7. The malignant gland must be radiated by urethral and rectal exposures, and by needles inserted directly into the neoplasm in order to produce complete radiation of all portions.

8. It is demonstrated microscopically, that large doses of radium placed directly into the gland affect only a limited area; this is substantiated by the clinical findings which prove that the course of the disease after such treatments is but slightly affected.

9. In the parts of the gland affected by the radium, fibrous tissue is produced which enmeshes and compresses the cancer cells, preventing their further proliferation. If this process could be brought about in the entire growth, complete cessation of the disease would result.

10. Sacral anesthesia is a useful adjunct in the application of radium needles, making it possible to place the radium accurately and to change the position of the needles without pain; thus a more thorough radiation of the gland is accomplished.

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THE ROENTGEN-RAY DIAGNOSIS OF NON-OPAQUE FOREIGN BODIES IN THE AIR PASSAGES*

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AT the meeting of the Eastern Section of the American Roentgen Ray Society in January, 1920, Dr. Jackson,[1] Dr. Spencer and I presented a paper on this same subject. The object of the paper was to bring to the attention of the roentgenologist this very important group of foreign body cases, to impress upon him the serious nature of the condition, to describe briefly the symptoms and physical signs, to demonstrate the roentgenologic evidence, and to illustrate the value of cooperation between the bronchoscopist and the roentgenologist. The paper from the roentgenologic point of view was based on the study of six cases.

Dr. Samuel Iglauer published two articles,[2] one in 1911 and the other in 1912,[3] in which he described the roentgenographic appearance of overdistention of the lung of the affected side and displacement of the mediastinal structures toward the unaffected side in peanut cases. One of these articles contained the reproduction of a roentgenogram which showed the signs very beautifully. He also described the mechanism by which the emphysema was brought about, his theory being, "The physiologic inspiratory expansion of the bronchus produced a valve-like action, admitting and entrapping the air beyond the foreign body, and this undoubtedly led to an emphysema of the right lung,"—the case being one of peanut in the right bronchus.

It seems appropriate to present our further studies of this class of cases for the reasons that the evidence is of increased value because of the constancy of it, that there are a few important points not mentioned in our former paper, and, further, that there are variations and complications at times which deserve more careful consideration. Then, too, there have been twelve cases in which, because of history, symptoms, or signs, foreign body has been suspected but not actually recovered. A study of this group serves to illustrate some of the problems in differential diagnosis.

It is extremely important that every roentgenologist should be thoroughly familiar with these signs, for he is often called upon to determine whether or not a foreign body is present, and upon his decision rests perhaps the very life of the patient.

The present paper is based on a study of 56 cases in which foreign body was present or suspected, and all of these with two exceptions (pebble, F. B. No. 624 and cockle bur, F. B. No. 723) have come to Dr. Jackson's Clinic at the Jefferson Hospital since January 1920.

The cases studied are listed in Table I.

TABLE I

	R. B.	L. B.	Trachea	
Peanut kernel	16	4	2	22
Watermelon seed	1	2	5	8
Corn	..	2	2	4
Almond kernel	2	..	..	2
Walnut kernel	1	..	..	1
Chestnut kernel	..	1	..	1
Coffee bean	..	1	..	1
Navy bean	..	1	..	1
Peanut shell	..	..	1	1
Cockle bur	..	1	..	1
Corn stalk	..	1	..	1
Pebble	1	..	..	1
				44
Suspected cases	12	..	..	12
Total	..	..	..	56

A brief analysis of the proven cases serves to show the constancy with which diagnostic roentgen-ray evidence and localizing signs are present. Although the analysis does not show it, compensatory emphysema is always present in the unaffected lung. The cases are listed in the sequence of their appearance and the "F. B. No. " is that given by Dr. Jackson.

* Read at the Twenty-Second Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

FIG. 1a.

FIG. 1b.

FIG. 1. F. B. No. 802. Signs are not marked, but positive. Exposures were made during quiet breathing: (*a*) Inspiration; (*b*) Expiration; (*c*) After removal.

The roentgen-ray signs of acute obstructive monolateral emphysema are:

1. Increased transparency of the affected lung.
2. Depression and partial fixation of the diaphragm on the affected side.
3. Displacement of the heart and mediastinal structures away from the affected side.
4. Increased excursion of the diaphragm on the unaffected side, due to compensatory emphysema.

The diaphragmatic signs are the most important, for by them alone can one rule out compensatory emphysema.

In our former paper, sign No. 4 was suggested as "Increased density in the lung shadows on the opposite side due to retained secretions." We now feel that this is not sufficiently constant to be classed with those mentioned above. It does occur in a small percentage of cases and is present probably for the reason that the foreign body has shifted from one side to the other and caused an inflammatory reaction, the products of which add to the density of the unobstructed lung, especially at expiration.

The above enumerated signs are present in proportion to the degree of expiratory obstruction. They may be so slight that repeated observations and exposures are necessary to establish them beyond doubt, or it may be necessary to make the child cry in order to record the changes that

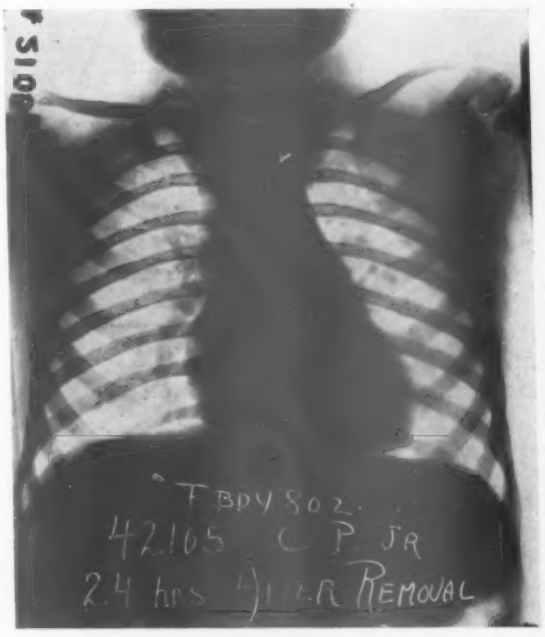

FIG. 1c.

TABLE II

F. B. No.	F. B.	Location	Sojourn	Age	Roentgenologic Signs				
					Ob. Emph.	Atelectasis	Retained Secretions	Abscess or Bronchiectasis	Remarks
624	Pebble	R. Bron.	3 days	4 yrs.	R. lung				
723	Cockle bur	R. Bron.	1 yr. 5 mos.	16 yrs.				R. lower lobe	
769	Peanut	Trachea	1 day	6 yrs.	R. and L. lung				
781	Peanut	R. Bron.	7 days	3 yrs.	R. lung		R. upper lobe		
783	Corn	Trachea	4 days	2½ yrs.	Limited motion both diaph.		L. lung		Shifting F. B.
787	Peanut	L. Bron.	17 days	21 mos.	L. lung		R. lung		Shifting F. B.
789	Peanut	R. Bron.	19 days	2 yrs.	R. lung				
790	Corn	Trachea R. Bron.	6 days	5 yrs.	R. lung				Shifting F. B.
799	Peanut	R. Bron.	16 days	3 yrs.	R. lung				
800	Peanut shell	Trachea	2 hrs.	14 mos.	R. and L. lung				
802	Peanut	R. Bron.	9 days	3 yrs.	R. lung				
815	Peanut	L. Bron.	4 days	2½ yrs.	L. lung				
819	Watermelon seed	Trachea	6 days	4 yrs.	No *x*-ray signs except inflam., thickening at hilus on both sides				
824	Watermelon seed	L. Bron.	4 days	5 yrs.	L. lung (no *x*-ray signs when F. B. was in trachea at first observation)				Shifting F. B.
827	Watermelon seed	Trechea	4 days	2½ yrs.	L. lung		R. lower lobe		Shifting F. B.
828	Peanut	R. Bron.	11 days	3 yrs.	R. lung				
832	Chestnut	L. Bron.	10 days	2½ yrs.	L. lung				Shifting F. B.
833	Coffee	R. Bron.	14 days	2 yrs.			R. lower lobe		
838	Corn	L. Bron.	1 day	1 yr.	L. lung				
839	Watermelon seed	R. Bron.	3 mos.	22 mos.	R. lung slight				
846	Peanut	R. Bron.	18 days	23 mos.	R. upper lobe			R. lower lobe	
856	Peanut	R. Bron.	3 mos.	21 mos.	R. lung				Unusually mild reaction
871	Peanut	L. Bron.	3 mos.	2 yrs.	L. upper lobe			L. lower lobe	
872	Almond	R. Bron.	3 mos.	2 yrs.	R. lung				Physical signs of abscess not confirmed by *x*-ray

TABLE II (Continued)

F. B. No.	F. B.	Location	Sojourn	Age	Roentgenologic Signs				
					Ob. Emph.	Atelectasis	Retained Secretions	Abscess or Bronchiectasis	Remarks
875	Peanut	R. Bron.	4 days	2 yrs.	R. lung				
877	Peanut	R. Bron.	5 days	3 yrs.	R. lung				
880	Peanut	R. Bron.	9 days	13 mos.	R. lung				Shifting F. B.
884	Peanut	R. Bron.	2 days	31 mos.	R. lung				Multiple F. Bs.
890	Peanut	R. Bron.	7 days	4 yrs.	R. lung		R. lower lobe		
891	Peanut	Trachea	8 days	27 mos.	Not studied before removal				
892	Peanut	Trachea	2 days	2 yrs.	R. and L. lungs				
898	Corn stalk	R. Bron.	5 wks.	15 yrs.				R. lower lobe	
900	Bean	R. Bron.	1 day	3½ yrs.		Entire R. lung			
904	Peanut	L. Bron.	13 days	5½ yrs.	L. upper lobe	L. lower lobe			
905	Peanut	R Bron.	7 days	3 yrs.	R. lung				
911	Watermelon seed	Trachea	4 days	11 mos.	R. lung (?)				Shifting F. B.
919	Watermelon seed	Trachea	3 days	2 yrs.	No *x*-ray examination before removal				
918	Watermelon seed	Trachea	3 days	4 yrs.	No *x*-ray signs				Movable F. B.
920	Peanut	R. Bron.	15 days	3 yrs.	R. lung				
927	Watermelon seed	Trachea	5 days	5 yrs.	No positive signs				
928	Watermelon seed	Trachea	2 mos. 8 days	15 mos.	No positive signs				
931	Corn	Trachea	16 days	3½ yrs.	R. and L. lungs				
932	Peanut	R. lower bron.	45 days	56 yrs.	R. lower lobe				
936	Peanut	R. Bron.	29 days	16 mos.	R. lung				

The following signs may be elicited by the roentgen ray, either alone or in combination, when the foreign body is lodged in a bronchus:
1. Obstructive emphysema, monolateral. 2. Retained secretions, or drowned lung. 3. Abscess formation, or septic pneumonitis. 4. Atelectasis in part of a lobe or perhaps one entire side.

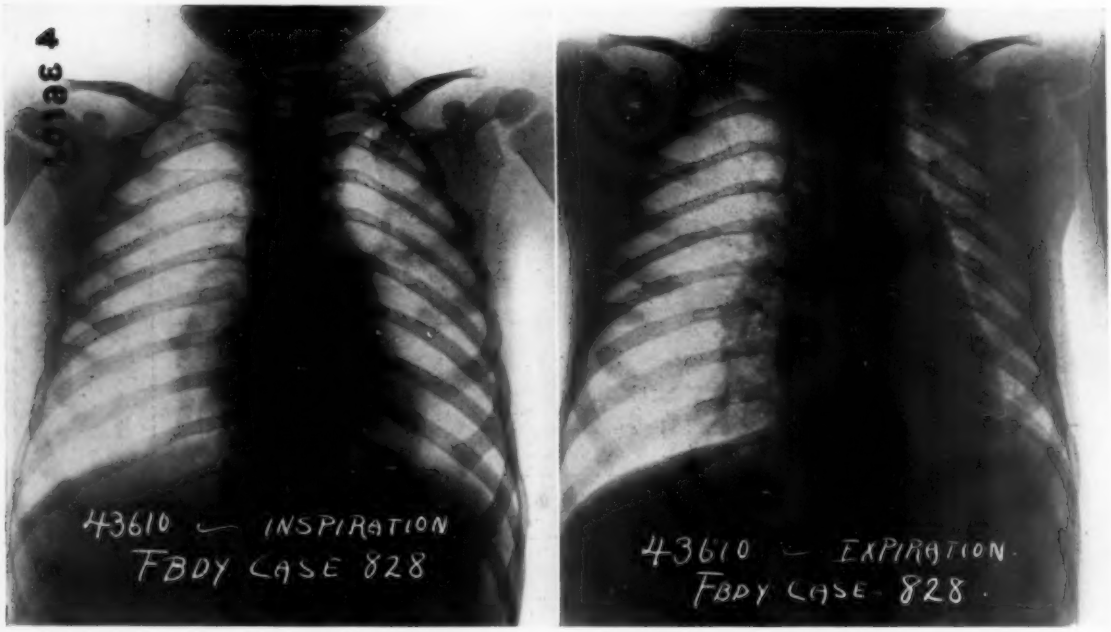

FIG. 2a. FIG. 2b.

FIG. 2. F. B. No. 828. Signs are quite marked. High degree of expiratory obstruction. (*a*) Inspiration; (*b*) Expiration; (*c*) After removal.

occur between full inspiration and full expiration (Fig. 1, a, b, c). On the other hand, they may be so pronounced that even at full inspiration the displacement of the diaphragm and mediastinal structures plainly indicate obstructive emphysema on the affected side. The most important point to remember is that the signs are accentuated most at the end of expiration—a point which was not made clear in our former report— and no examination is complete without instantaneous roentgenograms at both full inspiration and the end of expiration (Fig. 2, a, b, c).

We have reasons to believe that these signs may be elicited very soon after the foreign body lodges. In F. B., No. 824, at the first examination, no obstructive evidence was obtained,—the foreign body being in the trachea—but on the second examination, within a few hours after the first, there was most positive evidence of obstructive emphysema of the left lung (Fig. 3, a, b, c). The foreign body had in the meantime lodged in the left bronchus. In F. B., No. 838, the signs were present at the first observation, and the foreign body had been present only one day. We believe further that the inflammatory

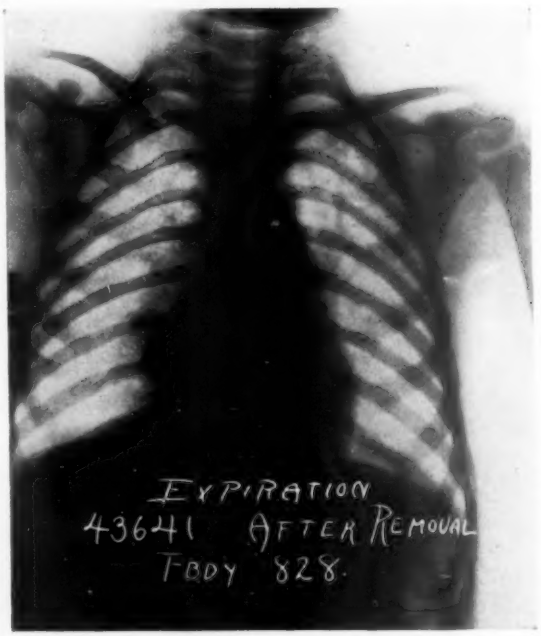

FIG. 2c.

reaction, especially edema, plays an important rôle in the mechanism of obstructive emphysema when the foreign body is of irregular shape, but that the signs may be elicited very promptly if the foreign body is of such shape that it will markedly obstruct

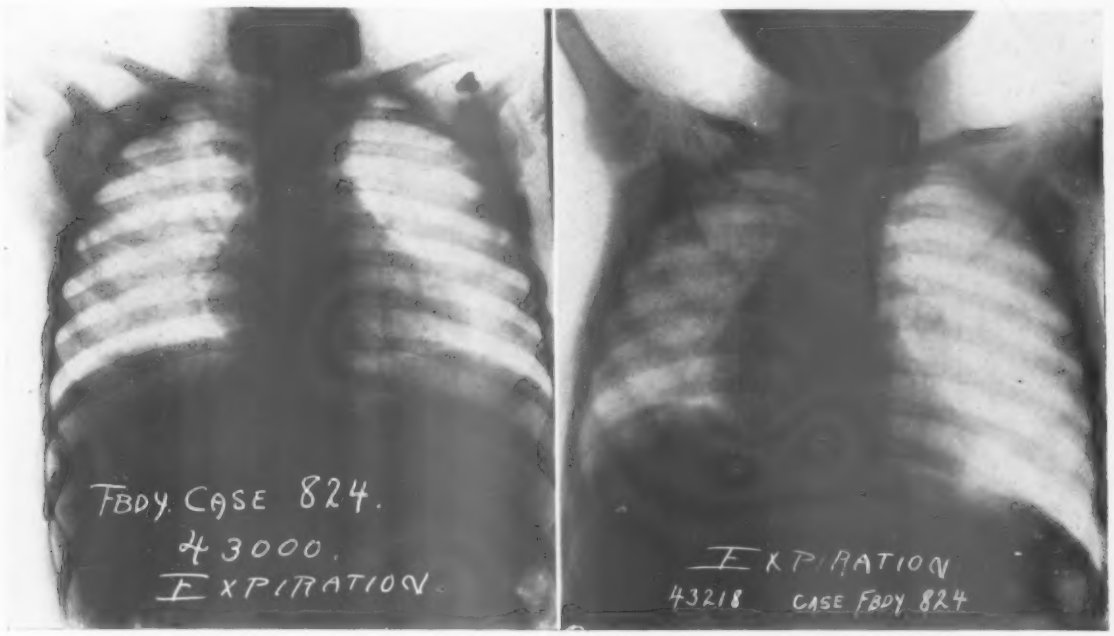

FIG. 3a. FIG. 3b.

FIG. 3. F. B. No. 824. No evidence of foreign body at first examination. Marked expiratory obstruction of left lung at second examination. Foreign body had shifted from trachea into left bronchus. (*a*) Expiration, first examination; (*b*) Expiration, second examination; (*c*) Expiration after removal.

the inspiratory current and almost completely obstruct the expiratory current.

Slight evidence of these signs is occasionally present for a period of hours after removal of the foreign body if the inflammatory reaction has been severe, but if it is at all striking or persists after twenty-four hours another foreign body must be assumed to be present until proven otherwise. In F. B., No. 884, the signs were present after removal of the first foreign body, became still more positive and remained so on subsequent days until a second fragment of peanut was removed. Following removal of this, the child coughed up a third fragment on its way to the ward, after which the signs of obstructive emphysema disappeared entirely and the child promptly recovered (Fig. 4, a, b, c).

We have noticed that the signs vary from day to day to some extent, but we are strongly of the opinion that they will remain positive as long as the foreign body remains in the bronchus, or until some change occurs distal to the foreign body to prevent further ingress of air. In case No. 789, peanut, there was a sojourn of nineteen days in a child two years of age; in No. 839, watermelon seed, the signs were positive after a sojourn of three months; and in No. 932, the signs were positive when the foreign body, a

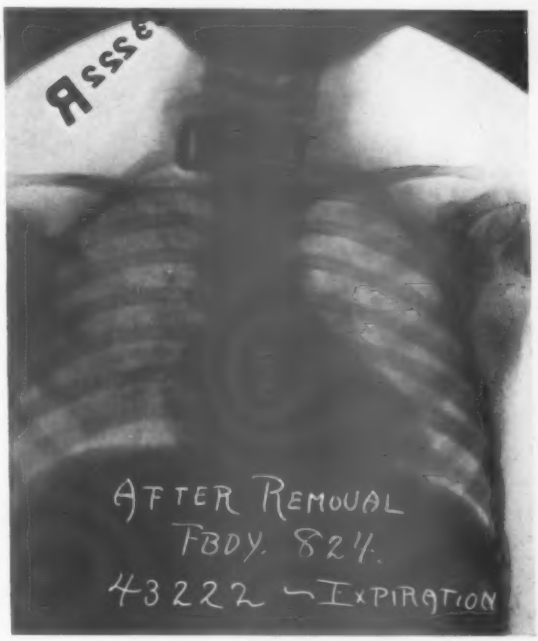

FIG. 3c.

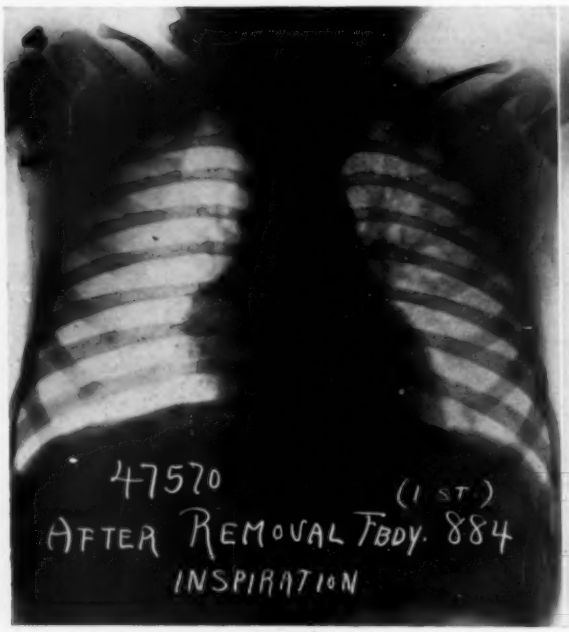

FIG. 4a.

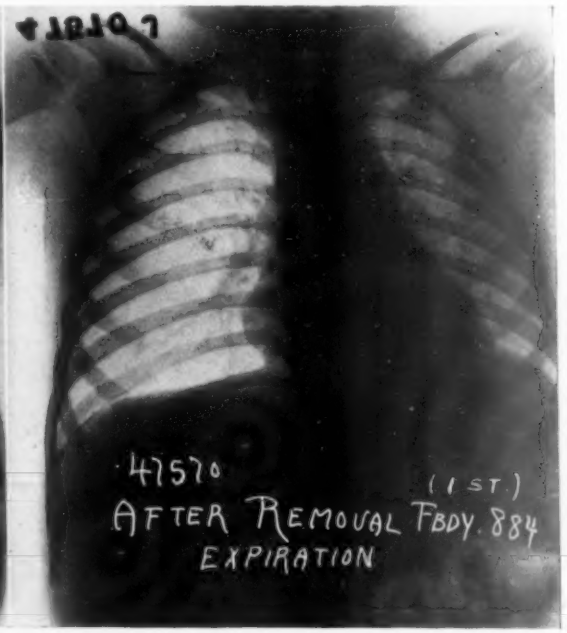

FIG. 4b.

FIG. 4. F. B. No. 884. Expiratory obstruction of right bronchus quite positive after removal of first fragment of peanut kernel. Signs are absent after removal of second fragment and expulsion of a third fragment. (*a*) Inspiration, after removal of first fragment; (*b*) Expiration, after removal of first fragment; (*c*) After removal of second fragment and expulsion of third fragment.

portion of peanut kernel, had been lodged in the right lower lobe bronchus forty-five days, but in this case, a man aged fifty-six years, the upper lobe was not involved (Fig. 5, a, b).

Obstructive emphysema may be present in an upper lobe with beginning abscess or increased density due to retained secretions in the lower lobe, or, one portion of a lobe, usually the dependent portion, may contain sufficient secretions to cast quite positive shadow, while the rest of the same lobe shows evidence of air distention. It requires very careful observation to elicit these combinations of signs.

We have never seen evidence of obstructive emphysema in an upper lobe with normal function and normal shadows in the lower lobe, but theoretically it might occur.

Retained secretions beyond the foreign body may collect in sufficient amount to produce a shadow of increased density in the dependent portion of the lung involved. This condition has been described by George C. Johnston as "drowned lung." It is more or less filmy in appearance, the bronchial shadows being visible. It is difficult sometimes to differentiate this from the early stage of actual abscess. In the later stages of abscess, the shadow is much more dense, the bronchial detail is lost, and the edges

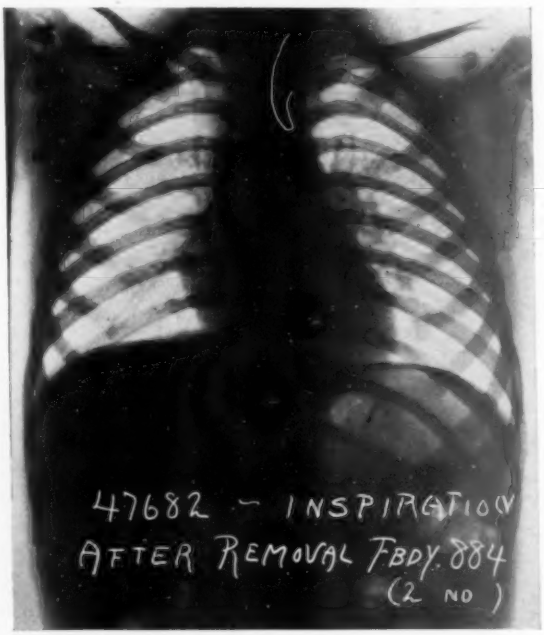

FIG. 4c.

have a ragged appearance, and more or less round shape. In the one case when the area is drained through the bronchoscope, the products are mostly of a thick mucous character, while in the other, pus is clearly and bountifully obtained. After removal of the foreign body and bronchoscopic drainage of retained secretions, the lung shadows approach the normal. In case of recognized, are practically diagnostic of foreign body. This condition is frequently seen in metallic foreign body cases, and has the same appearance as in the organic foreign body cases. On the other hand, the absence of such sign has no negative diagnostic value.

We know that these foreign bodies have a tendency to dislodge from time to time,

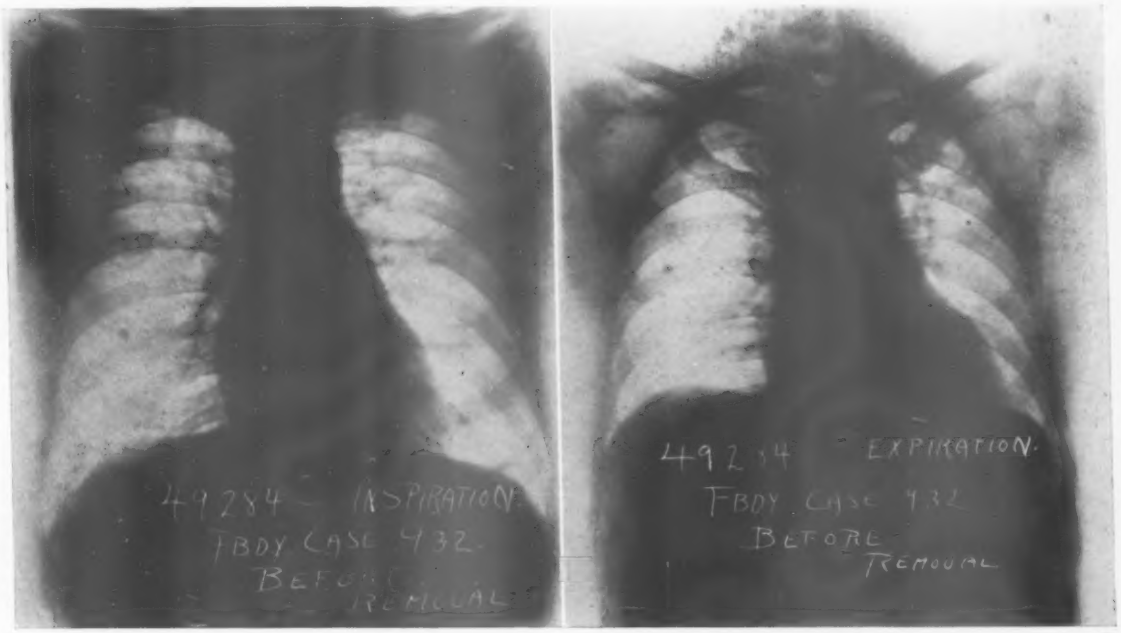

FIG. 5a. FIG. 5b.

FIG. 5. F. B. No. 932. Expiratory obstruction of right lower lobe in a man 56 years of age. Note that the upper lobe is not involved, and that displacement of the heart is more striking than fixation of the right diaphragm. (*a*) Inspiration; (*b*) Expiration.

abscess, there is the irregular density of tissues thickened by the infection. One rarely sees a cavity after such drainage, but may later find evidence of bronchiectasis.

We know of no law controlling the collection of retained secretions in amount sufficient to cast a positive shadow, unless it is one based entirely on the mechanics of the situation,—that is, that the thick mucus and products of edema collect beyond the foreign body and by force of gravity together with the relatively strong current of inspired air go to the dependent portion of the lung, where they are not influenced by the relatively weak current of expired air, the coughing effort, or physiologic expulsory functions.

Drowned lung shadows, when definitely and it is probable that each time the foreign body moves upward, the secretions below are evacuated to some extent. Then, too, the lymphatics must take care of a considerable quantity. By referring to the analysis, it will be seen that in F. B. No. 787 a quantity was present in a peanut case of seventeen days, whereas in F. B. No. 839, a watermelon seed had been present three months and the lung shadows were clear. In this study, roentgenographic signs of retained secretions were present in six cases; of abscess, in three cases.

Abscess is necessarily the result of infection. It seems remarkable, considering the degree of inflammation and trauma, that infection does not follow more frequently. Of course, such a result will eventually

occur if the foreign body remains long enough, regardless of the nature of the foreign body.

Atelectasis of the entire right lung was present in F. B. No. 900, a bean lodging in the right bronchus only one day. The extreme displacement of the heart and mediastinal structures as well as the diaphragm could not be explained in any other way. This lung was expanded to almost its normal capacity within a few hours after removal of the bean (Fig. 6, a, b). F. B. No. 904, a portion of peanut kernel produced atelectasis of the left lower lobe and obstructive emphysema of the left upper lobe (Fig. 7, a, b). In this instance the atelectatic lobe contained a considerable quantity of secretions, but the marked displacement of the heart toward the affected side determines clearly the element of atelectasis.

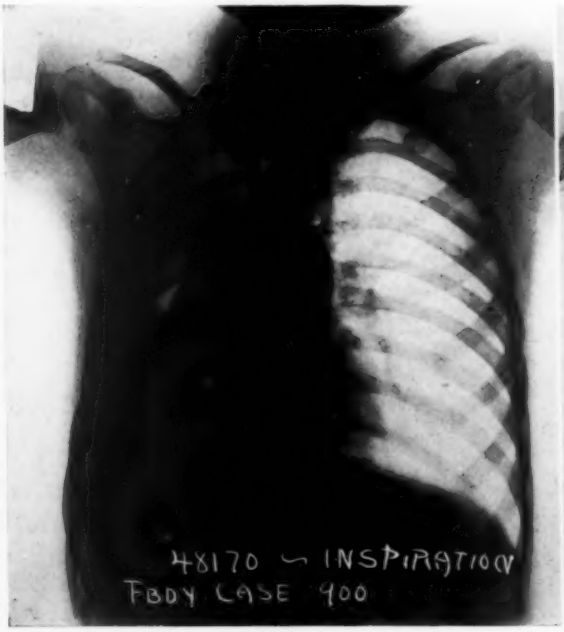

FIG. 6a.

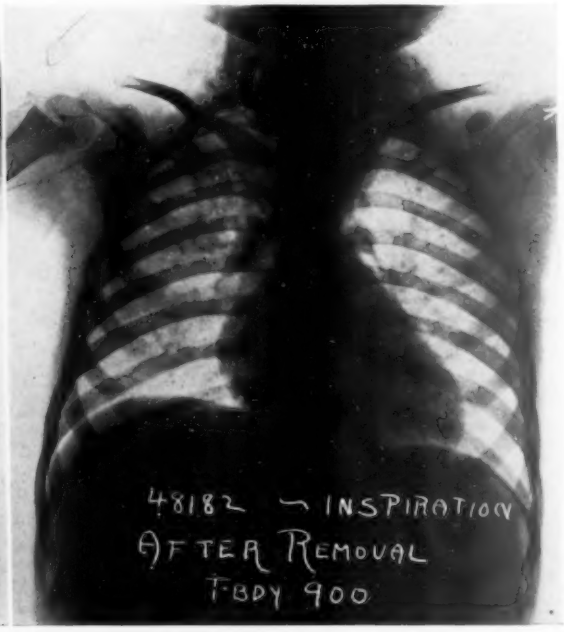

FIG. 6b.

FIG. 6. F. B. No. 900. Complete atelectasis of right lung. Note marked displacement of heart, and remarkable return of function a few hours after removal of bean. Compensatory emphysema of left lung before removal. (*a*) Inspiration before removal; (*b*) Inspiration a few hours after removal.

Childs,[4] in a report of six cases of foreign body in the respiratory tract, cites two instances of navy bean as the intruder. In case No. II of his article, atelectasis was present. In his other bean case, No. III of his report, he interprets the dense shadow of the left chest as being due to "complete consolidation of the left lung." We believe that his excellent roentgenogram shows a definite degree of atelectasis. A completely consolidated lung should not diminish in size and therefore not permit marked displacement of the heart and contraction of the left chest wall, such as is beautifully shown in his roentgenogram.

Fletcher[5] also reports the presence of atelectasis in the case of a navy bean as a bronchial foreign body.

It would seem probable that atelectasis follows only when the foreign body completely obstructs the bronchus both to ingress and egress of air, the residual air being more or less rapidly absorbed.

The signs of atelectasis are:

1. Displacement of the heart to the affected side.
2. Retraction upward of the diaphragm.
3. Marked density of shadows in the area involved.

It is necessary to determine that the patient has not previously had an empyema, since all of these signs may be present in certain of its stages. Atelectasis has been

present in a few other of Dr. Jackson's cases, in which the foreign body was also opaque. These are not included in the present analysis. When definitely proven to be present, atelectasis is diagnostic of foreign body, as well as of its location. Compensatory emphysema is present in the other lung.

Tracheal foreign bodies may not give definite roentgen-ray signs, but when they are present are nearly as positive as the signs of bronchial intruders (Fig. 8, a, b). Fortunately, when they do not present the roentgen-ray signs, they usually do present the most striking and positive physical signs.

Dr. Jackson[6] says: "Any object small enough to pass the glottic chink yet too large to enter either main bronchus may be found." In the same treatise, he also discusses the influence of shape and character of surface on the location of the object. Again, the mechanics of the situation determine the presence or absence of roentgen-ray signs. For instance, a watermelon seed, large enough to enter the trachea, may be too large to enter a bronchus, and, because of its flat shape, may allow free passage of air both during inspiration and expiration, so that obstructive emphysema may be entirely absent. In five of the nine cases of watermelon seeds included in this study, roentgen-ray signs were absent. However, in one of the five, at a subsequent observation, there was positive evidence of obstructive emphysema of the left lung (F. B. No. 824). The seed had become at least temporarily impacted in the left bronchus. Of the other four cases of watermelon seed, three showed signs of monolateral obstructive emphysema, and one was not examined before removal.

On the other hand, a tracheal foreign body that does not move freely, and, because of its size and shape, interferes with respiration to a considerable degree, will manifest the signs of obstructive emphysema of both lungs. The diaphragm is depressed on both sides and is lower on expiration than on inspiration, being overcome by the more powerful intercostal muscles of respiration; the heart is more in the median line and more vertical, appear-

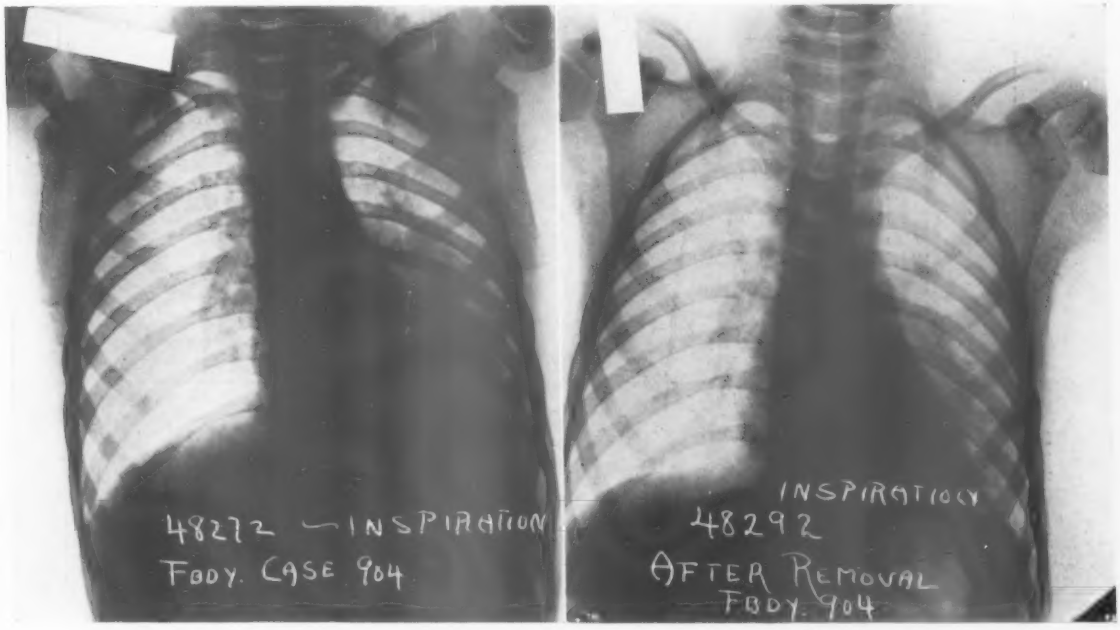

FIG. 7a. FIG. 7b.

FIG. 7. F. B. No. 904. Partial atelectasis and retained secretions left lower lobe. Slight obstructive emphysema left upper lobe. Compensatory emphysema right lung. (*a*) Inspiration before removal; (*b*) Inspiration after removal.

TABLE III

Case No.	History	Obstructive Emphysema	Dense Pathology	Bronchoscopic Findings	End Results and Remarks
46,309	No history of aspiration	R. lung	R. upper lobe	Previous bronchoscopy negative; ulcers seen	Tracheotomy; death from severe gastroenteritis
41,741	No history of aspiration	Both lungs (slight)	R. upper lobe; cleared up gradually	No bronchoscopy	Tracheotomy; recovery
45,080	History of peanut aspiration	None	None	None	No development of symptoms of arachidic bronchitis
45,155	History negative	R. lung; due to external pressure	R. upper lobe, probably suppurating peritracheal gland; gradually cleared	Bronchoscopy for diagnosis; obstruction of R. main bronchus; no foreign body found	Tracheotomy; recovery
46,463	Positive peanut	None	R. upper lobe	No foreign body found	Physical signs were positive; F. B. probably expelled before *x*-ray examination; recovery
47,280	Negative	Both lungs; 2d exam. R. lung	Enlarged gland, compressed trachea and obstructed R. bronchus; later broke down and caused rather extensive lesion	No bronchoscopy	*X*-ray treatment; temporary improvement; pneumonic process; recovery
47,552	Suggestive; popcorn	L. lung	None	No foreign body found; diffuse tracheobronchitis; L. bronchus much swollen	Tracheotomy; recovery; F. B. probably expelled; convalescence similar to proven cases
48,103	Positive almond	L. lung	None	Tracheobronchitis, typical of arachidic bronchitis; no F. B. found	F. B. probably expelled; signs disappeared after bronchoscopy; convalescence like proven cases; recovery
47,904	Negative	None	Larynx; seen clearly on film	Papilloma removed from larynx	Recovery
48,241	Suggestive pretzel	None	None	Papilloma removed from larynx	Recovery
48,367	Positive timothy head	None	R. middle lobe; three days later this had cleared and R. lower lobe was consolidated; cleared like lobar pneumonia	No bronchoscopy	Recovery as from lobar pneumonia
49,232	Negative	None	None	Diffuse tracheobronchitis; influenzal type	Recovery

ing in its entirety above the diaphragms. These signs will be very slight or quite positive, according to the degree of obstruction. Occasionally they are distinguishable only by comparing roentgenograms made after removal with those made before removal. They are always more pronounced if the child struggles or cries, but it frequently occurs that the patient will paroxysmal cough, wheeze, etc., to a sufficient degree to warrant roentgen-ray examination.

It is difficult to estimate the value of the study of these cases because of lack of proof in some of them, especially those with positive or suggestive history of aspiration of foreign bodies, but we feel that our assumptions as to probabilities are fair.

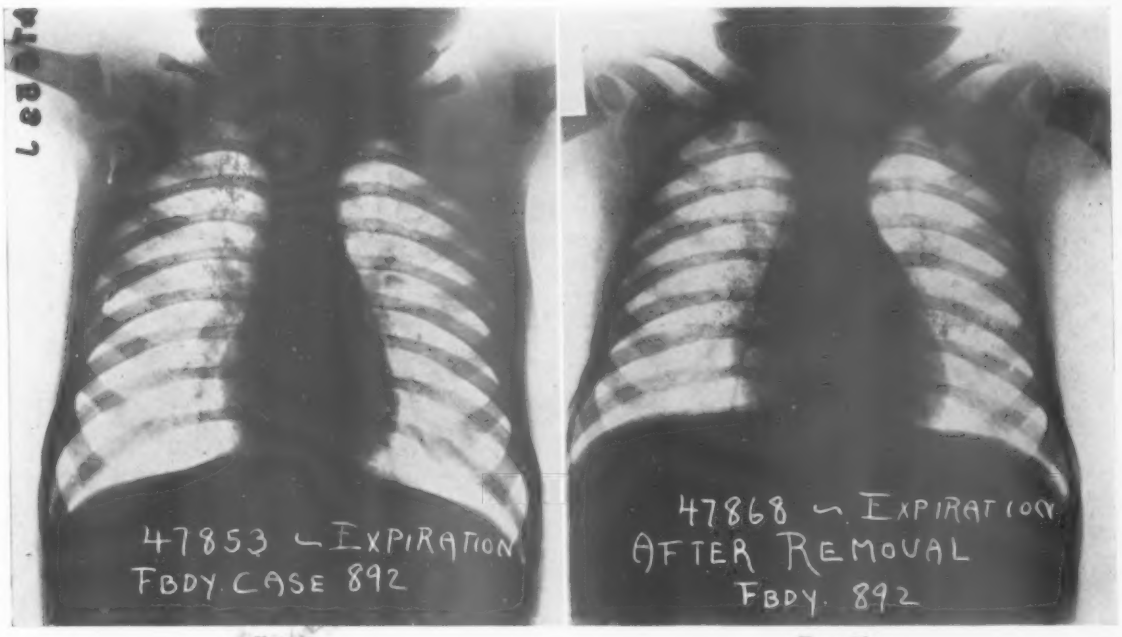

FIG. 8a. FIG. 8b.

FIG. 8. F. B. No. 892. Quite marked depression of the diaphragm on both sides, rotation of heart, overdistention of both lungs. Peanut in trachea. (*a*) Expiration before removal; (*b*) Expiration after removal.

breathe quietly with the utmost determination, for the reason that any violent expiratory effort is apt to force the foreign body upward against the glottis and produce an agonizing paroxysm.

A separate brief analysis of the twelve suspected cases is given to avoid confusion with proven cases of foreign body. Case number refers to serial number of *X*-Ray Department records. The number given is for the first examination only. All cases were examined repeatedly; a new serial number, given each time, is not shown here.

Of the twelve cases listed and analyzed as suspected or unproven cases, all had some or all of the symptoms and signs of foreign body, usually severe dyspnea,

Case 46,309 was particularly puzzling. Signs of obstructive emphysema were quite positive, especially at the second examination. The dyspnea was distinctly expiratory. The dense pathology was not extensive and we could not determine that there was pressure stenosis from without. The bronchoscopic examination was made before the child came to Jefferson Hospital, so that we were unable to exclude the element of trauma. Bronchial ulcers were reported present. The child was not in condition at any time for a second bronchoscopy. Even though the chest signs did disappear to some extent, the child developed a severe gastro-enteritis from which it died. One other point in the history was of importance. Ten days after

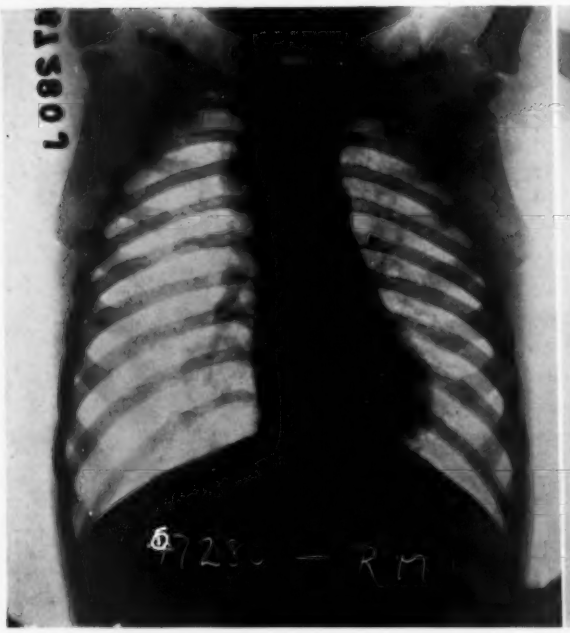

FIG. 9a.

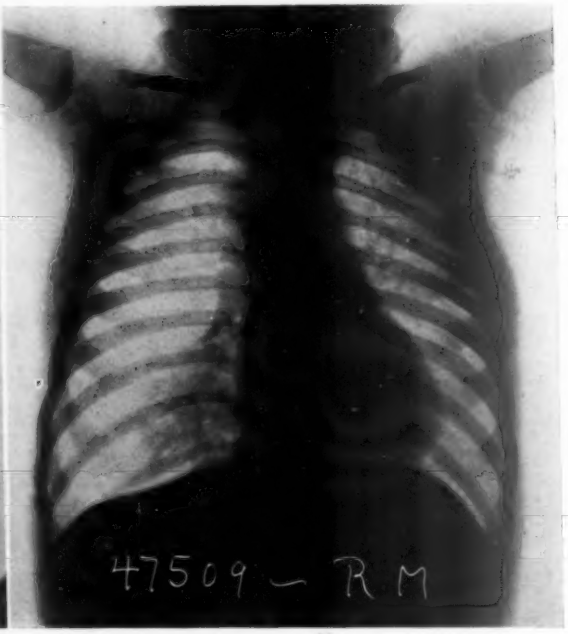

FIG. 9b.

FIG. 9. (*a*) First examination revealed enlarged glands compressing trachea and right bronchus; (*b*) Second examination after roentgen-ray treatment shows glands reduced in size; (*c*) Third examination after further treatment and probable breaking down of gland and spreading of infection. Patient recovered.

admission to Dr. Jackson's clinic, the child coughed up three fragments of soft consistency which on drying became very hard. Following this, obstructive signs diminished but did not entirely disappear. We feel it is entirely possible that a foreign body was present and in part remained.

Case 41,741 was probably one of diffuse tracheobronchitis complicating a pneumonia, and the slight obstructive emphysematons signs due to thick secretions. These signs disappeared gradually after tracheotomy and removal of secretions. At the first examination we believed a foreign body was present, but changed this opinion at subsequent observations.

Cases 45,155 and 47,280 were interesting because the cause of obstructive emphysema was shown to be due to pressure on the trachea or bronchus by greatly enlarged glands (Fig. 9, a, b, c).

Case 48,367 was especially interesting because of the positive history and the presence of roentgenographic evidence of lobar pneumonia without any characteristic signs of foreign body. The lung cleared as if by resolution, but the physical signs were atypical. Dr. Jackson was of the

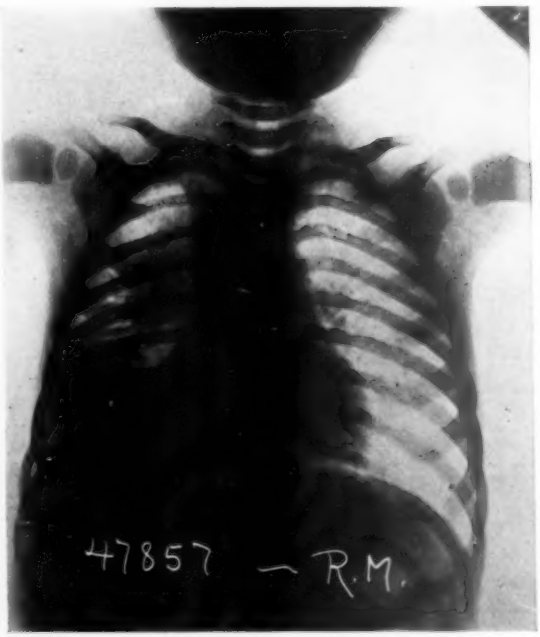

FIG. 9c.

opinion that the foreign body had been expelled before our examination, but had caused bronchial inflammation which complicated the physical signs of the pneumonia that intervened. It is a well proven

fact that bronchial foreign bodies are occasionally expelled spontaneously. Children rarely expectorate the secretions brought up by coughing, so that the organic foreign body may easily be lost.

It is not practicable to give detailed histories of these cases, even though they are extremely interesting and important, but they do support the brief analysis and assumptions shown above.

The handling of the patients is a matter of the utmost importance. They are generally dyspneic and apprehensive, and often greatly exhausted as well as toxic. Sudden shifting of the foreign body from a bronchus to the under surface of the glottis causes a violent paroxysm and may even produce sudden death, so that it is our rule to handle these children gently, I might almost say tenderly, and yet with a degree of firmness and alacrity that will permit of careful fluoroscopic study, as well as film exposures. We do not object to the child's crying, but do try to prevent struggling by holding the legs, arms and head firmly. This is especially important in making film exposures in order that the patient may be on the cassette and the exposure may be through the median line.

On the fluorescent screen one observes the movements of the diaphragm and heart, and the changes in the lung shadows due to entrance and exit of air. When the obstruction is slight, the lateral movements of the heart may be more striking than the limitation of motion in the affected diaphragm, and the heart moves away from the obstructed side at expiration. The more fixed and depressed the diaphragm, the greater is the lateral displacement of the heart. In severe cases, the affected diaphragm may be lower at expiration than at inspiration. Slight difference in transparency between the two lungs may escape detection by the screen, but be recognizable on the film exposed at the end of expiration. The screen examination gives immediate information, and one is sure to see the extremes of inspiration and expiration.

For roentgenographic study we use duplitized films and double screens. Exposures are always made at the end of inspiration and at the end of expiration, and it is sometimes necessary to repeat the exposures to make sure that they were made at the end of inspiration and expiration.

The exposures are all made with a constant tube-plate distance of about 36 inches (the greatest our apparatus will permit), in a small fraction of a second, probably one-fifteenth.

The patient lies on his back and if not entirely submissive we have nurses hold the arms, head and legs. If too quiet, and we are in doubt after the screen examination, we gently make the child cry a bit in order that we may get exposures at full inspiration and full expiration (Fig. 10, a, b, c). One must, as it were, "shoot on the wing" to get the exposure at the proper time, for rarely will the child take a full breath and hold it, or exhale and stop at one's bidding. The exposure at the end of expiration is always the important one. Exactly the same technique should be repeated after removal of the foreign body, and if the signs persist to an appreciable degree twenty-four hours after removal, a second foreign body should be accused until proven absent.

We have neither the space to include, nor the ability to describe, the physical signs and clinical diagnosis, but there are many features and variations that are unusual and puzzling to the clinician who has not had considerable experience in connection with a bronchoscopic clinic where the fortunate cases ultimately go for relief of some sort of obstruction to breathing. It is a fact, however, that in Dr. Jackson's clinic the diagnosis and localization, made from the history, physical signs, and clinical evidence, are extremely accurate. The reader is referred to the articles listed in the bibliography for information on this phase of the subject.

The roentgenologist should at least have as accurate a history as possible, not only as to the time of onset but particularly as to the nature of the intruder, and he should not on his own responsibility make a negative foreign body diagnosis, especially of such an object as a watermelon seed or other body that might be in the trachea and not produce marked obstruction. He should insist upon repeated examinations

FIG. 10a.

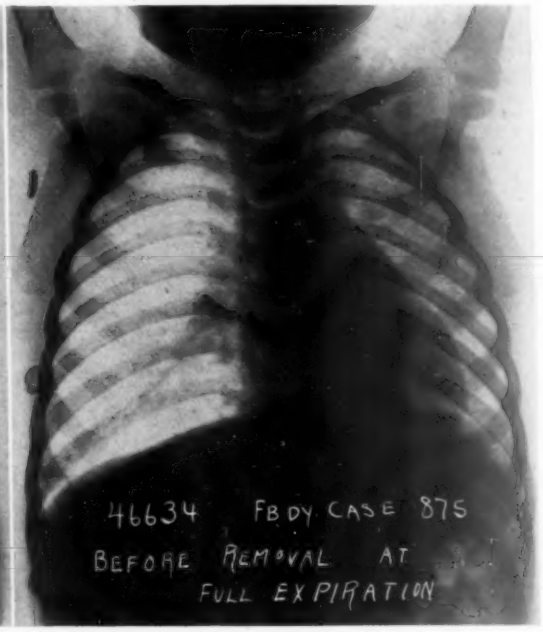

FIG. 10b.

FIG. 10c.

FIG. 10d.

FIG. 10. F. B. No. 875. This patient was unusually good and breathed according to instruction. Note that in *a* at full inspiration, aeration of the two lungs is nearly equal, whereas in (*b*) the evidence of obstructive emphysema of the right lung is striking at the end of full expiration. Compensatory emphysema of left lung is quite evident. (*c* and *d*) All signs disappear after removal of foreign body.

unless all signs and symptoms disappear, and even then have the utmost respect for a positive history because of the delusive period of calm that Dr. Jackson has described.

We believe firmly that any organic foreign body lodged in the air passages will eventually cause death if not expelled or removed, and it is most dangerous to hope for spontaneous expulsion. On two occasions to our knowledge, physicians have told the parents that the "peanut" would dissolve. This is an error as unfounded as it is dangerous.

The writer is deeply indebted to Dr. Jackson for his interest and encouragement, as well as for his permission to use the material of his clinic in making this presentation.

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DISCUSSION

Dr. Gray. I had a case recently, a child approximately two years old that gave no definite history of aspirating peanuts but had been eating them. There developed shortly afterwards what appeared to be bronchitis. I went through the procedure which Dr. Manges has described, and could find no evidence whatever either on the fluoroscopic or plate examination of obstruction. There was some blurring and some haziness of the bronchial tree and the physical signs showed bronchitis on both sides. A negative report was given, but the child continued to have trouble and began to grow rather suddenly worse after a few weeks. It was again referred to me and this time I found a distinct consolidation which proved to be pneumonia, I recall, of the lower lobe of the right lung. Diagnosis of obstruction was then made and the case referred by me to Dr. Jackson, who removed several fragments of peanut from the bronchus leading to this lobe. I account for my failure to find any evidence when the case was first referred to me by the fact that the small fragments were merely acting as irritating foreign bodies without being obstructive. Later on, when the inflammatory process had persisted to such an extent as to obstruct the bronchus, the positive signs that I subsequently found showed themselves plainly. We are entirely too prone, when a vague, indefinite history of aspiration comes to us and we fail to find on first examination any evidence of obstruction or the foreign body, to dismiss the case with the statement that there is no foreign body. This case has proven to me that we should not do that, but should keep the case under observation for at least several months.

Dr. Stewart. I feel I cannot let this opportunity pass without the Society realizing the great advantage they have had in listening to this paper by Dr. Manges, who has had a very unusual opportunity in studying these cases. We have seen his gradual development in the work and I feel now that he is one of the best authorities on the subject of foreign body in the lung that we have among us. I therefore cannot pass without expressing my appreciation of his work as he has shown it to us today.

Dr. LeWald. I would like to state that the use of the Potter-Bucky diaphragm gives one a very decided advantage in studying the bronchi on the left side. I know of a case of a pin which was missed because it was in the left bronchus behind the heart shadow. If you will look at lung plates taken with the diaphragm, you will be able to trace the branches of the left bronchus well down behind the heart, and the lower lobe bronchi on each side can be traced in a most satisfactory manner.

I advocate the use of the Potter diaphragm in all cases where the foreign body is not immediately seen.

Dr. Kann. I want to thank Dr. Manges for the kind omission of my name in one of the cases. I want to add my words of felicitation to Dr. Stewart's. I think I have learned more in these few minutes than I have in a few years. I want to thank Dr. Manges again.

Dr. Keith. Those of us who have followed Dr. Jackson's work in opaque foreign bodies know how he emphasizes the use of lateral plates. I want to ask Dr. Manges if he has found lateral plates to be of any service.

Dr. Hickey. I think this brings out the fact that examination should be more than a matter of routine. One of our oculists in Detroit, if there was any injury to the eye, always assumed the foreign body to be present until it was disproved.

I think this should be the attitude of roentgenologists when they are called in consultation in these cases. I have had the opportunity of viewing them from both sides; from operating on them and from making diagnoses. When a case comes in with a suspicious history, the only safe thing to do is to assume a foreign body is there until you are quite sure it is not.

Dr. Manges (closing discussion). First in reply to Dr. Gray. Without having my case records here I am sorry I cannot give him a specific answer. I recall very definitely two cases—one was one of the cases I referred to in my paper—in which a foreign body was not found at bronchoscopic examination although there was bronchoscopic evidence of it. It was very clear in Dr. Jackson's mind, that a foreign body of the arachidic group had been there shortly before. Another time during a bronchoscopic operation he had removed some small fragments of peanut kernel that had become loose into the muco purulent material when suddenly a fragment of considerable size shot out through the bronchoscope and landed at a distance of three or four feet from where he was standing. This shows that there is always a possibility of the child getting rid of a foreign body without your knowing it. So I would like to take this attitude for the present; that unless you can demonstrate by roentgenogram some other cause for obstructive emphysema, you are safe in assuming that there is a foreign body present. Or when a child shows signs of dyspnea and you see no evidence of solid pathology in the lung field, the fact that the bronchoscopist does not find it at the time of operation, does not prove it is not there. In another case a child was under ether for forty-five minutes and one bronchoscopist failed to find a watermelon seed which was afterward removed by Dr. Jackson. We ought to assume that these signs do indicate foreign body unless we can prove there is something else present.

In Dr. Gray's case he said the foreign body was found, whereas he got no signs. I have tried to point out that in the less violent stages of reaction, and especially after the first severe attack is over, there comes a period of more or less calm when the foreign body goes to some place and stops. Then the child soon learns to breathe easily. If not, he gets these recurrent strangling attacks. The *x*-ray signs may be comparatively slight and you must get him to take full inspiration and full expiration, even if you have to gently make him cry.

With reference to lateral plates. When we see children who are dyspneic we handle them gently; we do not struggle with them; we do not examine them in the lateral views until we are convinced that there is no evidence of obstructive foreign body. We always use the lateral position in any other group of foreign body cases.

Dr. Hickey is right in saying that we should assume, when a child has recurrent strangling attacks, with or without history, that there is a foreign body there, until we prove there is not. One must repeatedly examine children. One time or another one will catch the foreign body producing obstruction.

A PRACTICAL METHOD OF ROENTGEN EXAMINATION OF THE HEART BASED UPON A STUDY OF ONE HUNDRED CONSECUTIVE NORMAL AND ABNORMAL CASES *

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THE fluoroscopic examination of the heart has been steadily growing in popularity in America, due to the perfection and precision of the method as developed in France. We feel that in experienced hands the information derived from its employment is both valuable and reliable. We have used it for a term of practically three years with increasing satisfaction. It seems unnecessary today to have to justify its position as a diagnostic aid. It is more in point to determine by actual test the value of the various interpretations. With this end in view we set out to examine roentgenologically 100 consecutive cases of normal and pathological hearts, by all the accepted methods. This procedure extended over a period of a little over four weeks. In the series are included 102 cases made up of 47 males and 55 females. Classified clinically 72 had normal hearts and 30 were pathological. The series was not large enough to include all the usual types of cardiac pathology. Little that is new is offered. Practically all the conclusions which we have reached are to be found in the excellent monographs of Vaquez and Bordet, Bardeen, and Van Zwaluwenburg.

Our procedure was first to take a standard 7 foot plate of the patient in the erect position in the manner described by Holmes and Ruggles. This method does not differ materially from the original procedure of Bardeen except that the patients were roentgenographed in the standing position. An orthodiagram was then made of each patient, the ray passing through the chest in a sagittal plane. The patient was then rotated to the left and observed in the right anterior oblique position. Finally each case was studied in the right posterior oblique position.

The area of the heart shadow on the 7 foot plate was measured by planimeter and was also computed by applying the method of Van Zwaluwenburg. The width of the chest wall of each case was measured and compared with the total transverse diameter (sum of MR and ML) of the heart according to the method of Danzer. The area of the orthodiagram was then measured by planimeter and also computed by the method of Van Zwaluwenburg.

From our comparison of the clinical value of the 7 foot plate and the orthodiagram we are convinced for several reasons that the latter is both the most valuable and the most accurate method. It enables us to establish the left auriculoventricular junction, which is the most important point on the heart silhouette. We can better outline the heart shadow and study its motion and dynamic relationship to the other organs of the chest, and are enabled to examine the heart in the oblique positions.

We shall discuss the results of our studies under four headings.

I. THE CARDIAC FORM

Roughly, we may say that the normal cardiac outline is represented by a series of curved lines. On the right side are two fairly broad curves, the lower one representing the border of the right auricle, and the upper, less well defined, representing, in most cases, the right border of the superior vena cava, sometimes the right border of the ascending arch. The latter soon becomes lost in the mediastinal shadows, to reappear on the left side as

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a semicircle representing the transverse portion of the arch. The left border of the descending arch may usually be distinguished as a straight line, approximately tangential to the shadow of the transverse arch. Immediately beneath the transverse arch one sees with greater or less distinctness, a curved line, convexity outwards, representing the ascending and transverse portion of the pulmonary arch. Its downward extension is in an almost straight line diverging slightly to the left and in some cases directly joining the left ventricle, which is the most conspicuous curve in the entire silhouette, running obliquely downward to the region of the apex beat and beyond to disappear beneath the left diaphragm. Its exact relation to the diaphragm depends upon the habitus of the patient. In slim individuals and in quiet respiration the apex may be entirely free from the dome of the diaphragm. In most normal individuals it is almost entirely exposed on deep inspiration, while in those with a high diaphragm, particularly the obese, the left ventricular border may be interrupted above the point where it reaches its maximum distance from the midline.

Interposed between the pulmonary arc and the ventricular arc in the majority of cases one sees a short straight line which represents the left auricle. It can be recognized from the ventricular shadow by the time of its contraction, its lower limit being marked by the point of minimum excursion.

The typical forms of heart silhouette, such as the drop heart of visceroptosis, transverse heart of old age and obesity, the boxing glove heart of mitral stenosis, the round heart of mitral regurgitation, snub nose or shoeshaped heart of the aortic regurgitation, the water-bottle shadow of pericardial effusion, have long been accepted among orthodiagraphers, and require no comment.

Vaquez and Bordet make use of various so-called diameters or chords to express numerically variations in size of different chambers of the heart. The basal diameter is drawn from the right auriculo diaphragmatic junction to the left auriculo ventricular junction, and corresponds to the oblique diameter of other authors. While this diameter is believed to measure the development of the base of the ventricles, in our experience we have found it of very little value. They have also introduced new diameters. The so-called left ventricular diameter extends from the left auriculo ventricular junction to the apex and it presumes to measure the longitudinal development of the left ventricle. While our experience with this diameter is limited, we see no advantage in it over the portion of the long diameter lying below and to the left of the oblique diameter. Vaquez and Bordet measure the degree of curvature of the left ventricular contour by the length of the chord of the arc which it describes. The right ventricular diameter is drawn from the right cardio diaphragmatic angle to the apex of the heart, and is presumed to measure the development of the right ventricle. The right auricular diameter joins the right cardio diaphragmatic junction to the auriculo caval junction and presumably measures the volumetric development of the right auricle. The left auricular diameter connects the most salient point of the left auricular contour with the median line, which is presumed to represent the interauricular septum. We would consider this latter diameter as of exceedingly doubtful value.

Van Zwaluwenburg's reductions of the changes in shape of the heart silhouette to a simple numerical expression have proved of extreme value in our hands. He pointed out in 1911 that the oblique diameter roughly corresponds to a dividing line between the auricles and ventricles; consequently the area above and to the right of this line can be considered an index of the auricular area, while that to the left and below represents the size of the ventricular portion of the heart. This relationship is expressed numerically by dividing the length of the auricular segment by the length of the ventricular segment of the long diameter, and is called the auriculoventricular (a-v) ratio, or the index of the heart. Normally it is approximately 0.55. With an increase in the auricular area its value rises. Relative increase in the ventricular size diminishes the index. While this index has many defects and varies

widely, depending upon the elevation of the diaphragm in normal subjects, and is disregarded in such cases except as an index to the posture of the heart, it is of great importance in the estimation of the relative size of the different chambers of pathological hearts.

The examination of the patient in the right anterior oblique position as advocated by Vaquez and Bordet, we consider of great practical value. These authors have shown that narrowing or obliteration of the upper third of the uniform clear stripe, which represents the posterior mediastinum signifies dilatation of the aortic arch; that encroachment in the middle third means enlargement of the left auricle; and modification of the lower third spells enlargement of the right auricle, sometimes of the right ventricle.

The examination of the patient in the right posterior oblique position to determine the depth of the ventricles has proven of less uniform value in our hands in patients of widely different habitus such as make up our population.

With the data from these examinations at hand we can furnish the clinician a quantitative estimation of the qualitative valvular changes which he has determined by auscultation.

II. THE CARDIAC SIZE

Shattuck in 1916 demonstrated by roentgen-ray methods the inaccuracy of percussion in the estimation of the size of the heart.

Danzer in 1919 revived the so-called cardio-thoracic ratio as a means of estimating cardiac hypertrophy. According to this method, the heart is said to be definitely enlarged when its total transverse diameter exceeds one-half of the internal diameter of the chest. In our series practically all the normal hearts with the exception of the visceroptotics show cardiac enlargement according to this method. Naturally the method ignores variation in position of the diaphragm. It would seem from our investigation that it is more accurately an index of the posture of the heart than of the size of the heart. Attention is invited to a few specific instances. Case 02 weighing 175 pounds, by planimeter showed a heart area well within normal limits. According to Danzer this heart shows 19 per cent enlargement. Case 022 of compensated mitral stenosis complicated by mitral regurgitation by planimeter showed an area of practically 160 per cent. According to Danzer this heart showed 1 per cent enlargement. Case 056, mitral regurgitation, according to planimeter showed a cardiac area of 167 per cent. According to Danzer this heart showed 20 per cent enlargement. Case 049, myocarditis without dilatation, according to planimeter showed an area of 150 per cent. According to Danzer this heart was not enlarged. Bardeen has shown that in order to use the transverse diameter of the heart as an index of area, the diameter should be squared. When this was done the variations were so great as to be impracticable.

While it will be seen at a glance that the cardio-thoracic ratio is grossly inaccurate considered as an index to the size of the heart, it is conceivable that it might be of limited assistance in determining changes in the cardiac condition as the result of treatment. A heart whose size is estimated at a time of dilatation with enlargement of the liver due to congestion and a consequent rise in position of the diaphragm will naturally show a high cardio thoracic ratio. Such a case after treatment and relief of cardiac dilatation and engorgement of the liver will show a true decrease of the cardio thoracic ratio due to the alteration of these two factors. However, we cannot see that the method has any degree of superiority over the simple super-position of one plate over another. In our practice, we report the MR and ML merely that the clinician may check his percussion.

Claytor and Merrill in 1909 proposed a method of approximation of the heart area based upon 70 per cent of the product of the long diameter and the transverse diameter. Objections to this method immediately arise. The method makes use of the transverse diameter. The factor .7 is an arbitrary factor. Their calculations have been proved inaccurate beyond a degree of practicability. This inaccuracy is largely due to the fact that the two

diameters used in computation intersect at angles of varying obliquity. In other words, the results are not independent of the position of the heart.

Holmes and Ruggles describe the method of estimation of heart size used at the Massachusetts General Hospital. The method is applicable to both the orthodiagram and the plate. The conventional MR and ML and longitudinal diameter are drawn. A line is drawn perpendicular to the long diameter extending to the right auriculo diaphragmatic junction or the most salient point on the right border. Another line perpendicular to the long diameter is drawn to the most salient point on the left border, or to a point on the border of the left auricular appendage. It is argued that the sum of the lengths of these perpendicular lines is increased with enlargement of the auricles, while the long diameter is increased with ventricular enlargement. Careful examination of the figures in Holmes and Ruggles' book lead us to believe that their perpendicular lines are not always drawn to even approximately the same points on the cardiac borders, and that consequently they are not comparing aliquot portions of hearts. They offer no method for computing the heart size. We can see no superiority of the broken perpendicular line over the greatest perpendicular to the long diameter erected in the closed cardiac outline.

Bardeen estimates the cardiac size by the use of the planimeter on a 7 foot plate. His tables of the heart size are the result of careful investigation and are fairly accurate. In our own series the discrepancy between the planimeter measurement of the orthodiagram and the planimeter measurement of the 7 foot plate has been practically constant, the average being 30 per cent. It is true, some of the figures vary widely from the constant, but these variations are due to qualities other than those of computation. In the first place our areas are uncorrected as we did not record the anteroposterior diameter of the chest in expiration. Other factors which account for the discrepancy of our figures may be mentioned. While the greatest care was exercised in taking our 7 foot plates we were impressed during the procedure with the apparent wide variation in distance of the chest wall to the plate in different patients due to peculiarities of stature and shape of the chest. Such variations naturally made considerable difference in the final computation. We believe the most important factor which entered into our error was the difficulty encountered in faithfully tracing the cardiac shadow. Our plates were technically good. However, we are dealing with a shadow of a moving body undergoing two separate and distinct types of motion, one that due to respiration, and the other due to the heart action itself. The heart is not an organ of uniform density. Often the apex which is the thinnest portion of the cardiac shadow would be lost behind a high diaphragm or diffused in the stomach bubble. In the cases of drop-heart or displacements and distortions due to pulmonary pathology, the right border was often overridden by the spinal shadow or lost in a maze of scar tissue, and it was only with the greatest difficulty that we could reasonably approximate the actual size of the shadow. These difficulties were not encountered in the orthodiagram. The very motion which rendered the outline of the apex indistinct in the plate aided the eye in tracing it before the fluoroscope. Likewise the motion of the borders and the ability to rotate the patient for a moment so as to locate the definite cardiac border in the oblique position aided in the accuracy of the orthodiagram.

The area of the heart shadow on the plate computed by applying thereto the formula for the area of an ellipse approximated the planimeter value surprisingly closely, the average error being about 2 per cent.

Naturally any accurate formula for the estimation of the size of the heart must make use of factors which are uninfluenced by the widely variable relative position of the heart. Van Zwaluwenburg has proposed that the heart be considered as an ellipsoid, and has applied thereto the formula for the area of an ellipse which is the product of the long diameter drawn through the center of the figure and the short diameter erected perpendicular thereto at the widest portion of the shadow,

multiplied by .7854. The result obtained by such computation in 60 cases showed an average error of a little over 3 per cent as compared with planimeter values, the greatest variation in any one case being 8 per cent in a heart of very doubtful and irregular shape. We have compared our results obtained by this method of computation with the planimeter values and have found an average variation of 2.6 per cent with the greatest variation of 6.9 per cent, 5 of our cases checked within .1 per cent, 22 checked within 1 per cent. 45 checked within 2 per cent, 62 checked within 3 per cent, 82 cases less than 4 per cent, 91 cases less than 5 per cent, 100 cases less than 6 per cent, 2 cases above 6 per cent. We have consequently adopted this procedure as a basis for estimating the cardiac area because it introduces a practically negligible factor of error.

Bardeen has shown that a considerable portion of the left auricular appendage and presumably a portion of the base of the heart is excluded from the closed cardiac outline formed by joining the right auriculo caval junction to the left auriculo ventricular junction in a gentle curve and similarly closing the lower opening. The method of estimation consequently does not include the entire cardiac area. However, the computed area is expressed as a percentage of the normal for the individual, and it is submitted that one can accurately determine the relative size of two similar bodies by estimating adiquot portions and expressing the same in a ratio.

Since the estimation of area is expressed in percentage of the normal, the computation can be further simplified by dropping the factor .7854 which appears in both numerator and denominator of the ratio. In practice, therefore, we multiply the long diameter by the short diameter and call this product the P O D (Product of Diameters). The product so obtained is divided by the corresponding value from a table of normal PODs of the basis of body weight. Hearts falling between 100 per cent and 110 per cent are considered normal according to the table which we employ (Fig. 1). This table of normals when plotted into a curve falls very nearly on a line representing the following relationship. The area in square centimeters is equal to a constant times the cube root of the weight in pounds squared. Except as to the constant, this table is in close harmony with the values for cardiac area deduced by Bardeen and is a simple expression of the hypothesis that the weight of the heart varies directly with the weight of the body and that comparable areas on similar volumes vary as the cube root of the

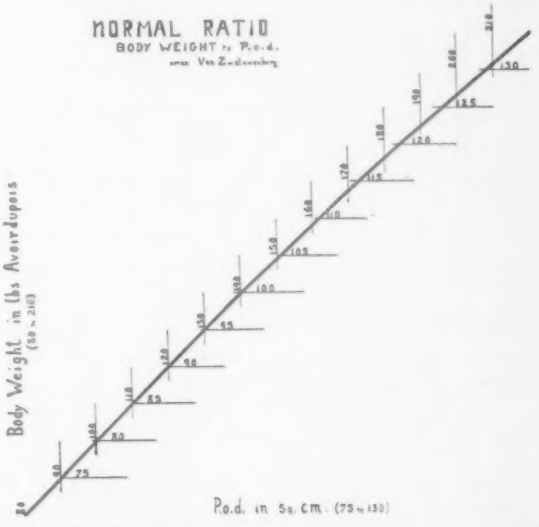

FIG. 1. Table showing relation of P O D to normal body weight. Experience has shown that this table is approximately 5 per cent too low. Consequently hearts ranging from 100 to 110 per cent of the values in this table are considered normal. After Van Zwaluwenburg.

squares of these volumes. Anatomically it has been repeatedly proven that the heart, of all the organs, is the most closely related in size to the size of the body as a whole.

While the size of the heart depends on a large number of factors including weight, habitus, position, excursion of pulsation, age, sex, and pulse frequency, it has been borne out by clinical experience, and there is abundance of proof both anatomical and roentgenological, that the weight is far the most important factor. As a matter of fact, height, sex, and age have a very subsidiary value except at the extremes where the estimation of their effect is rarely difficult. A factor which is of greater importance than any of these except weight is the pulse rate. We are in accord with Van Zwaluwenburg in the opinion that a rapid heart with an area of 110 per cent is

CLINICAL CLASSIFICATION OF ONE HUNDRED TWO CASES WITH MEASUREMENTS AND COMPUTATIONS

Case Number	Sex	Age	Weight	A-V Ratio, Orthodiagram	Total Transverse Diameter, Plate	Width of Chest Wall, Plate.	Per Cent Enlargement According to Danzer	Area Planimeter			Area Computation				Per Cent Discrepancy Orthodiagram Area Using Planimeter and P.O.D.	Clinical Classification
								Orthodiagram	Plate	Per Cent Discrepancy	Orthodiagram	Percentage	Plate	Per Cent Discrepancy		
NORMALS																
S014	M	30	193	0.53	14.4	27.1	6	100.8	136.6	34	95.8	98	144.7	51	−4.9	Pulmonary tbc. Underweight.
S017	M	24	140	0.70	12.6	24.8	2	96.7	125.8	30	93.5	119	126.4	35	−3.3	Pulmonary tbc. Underweight.*
077	F	37	133	0.64	11.5	23.4	0	71.7	93.1	29	73.0	98	97.1	33	+3.2	
S016	M	26	141	0.42	12.2	26.2	0	92.9	126.6	36	86.4	110	127.8	48	−6.9	
026	F	25	125	0.63	10.8	22.2	0	65.5	83.2	27	68.3	102	86.7	27	+4.3	
041	F	27	120	0.54	12.5	23.1	9	85.7	99.7	16	82.5	117	97.9	18	−3.7	Member of B family.†
124	M	29	175	0.70	13.9	27.5	1	97.0	112.2	10	101.3	110	111.6	10	+4.4	
045	F	47	148	0.52	13.0	25.8	1	88.6	124.0	41	90.3	109	125.5	30	+1.9	General paresis.
073	F	54	150	0.56	13.3	24.5	8	90.5	130.5	44	89.5	109	128.7	43	−1.6	
044	M	23	135	0.70	12.3	26.4	0	82.0	123.1	51	84.8	110	133.7	55	+3.4	
047	F	50	113	0.59	11.7	22.4	4	78.0	95.0	22	77.0	110	108.5	41	−1.3	Chronic pulmonary tbc.
023	F	24	135	0.54	14.0	24.0	16	85.9	117.1	36	88.8	114	118.1	33	+3.4	Member of B family.†
021	F	38	128	0.55	11.5	23.2	0	83.6	112.1	34	80.1	109	113.0	41	−4.2	Chronic pulmonary tbc.
02	F	62	175	0.50	13.4	22.5	19	91.7	105.3	14	94.2	103	106.7	13	+2.7	
S09	F	28	150	0.57	12.1	24.1	0	85.8	114.0	33	87.9	109	115.4	31	+2.4	
016	F	35	126	0.69	11.2	23.1	0	79.1	95.4	21	80.1	110	100.0	25	+1.2	
048	F	40	185	0.50	12.9	22.7	14	89.6	117.4	31	88.0	93	115.0	31	−1.8	High diaphragm.
054	F	23	130	0.59	10.3	24.2	0	74.6	86.0	15	71.5	96	90.2	26	−4.1	
051	F	36	125	0.60	12.0	23.8	1	84.7	107.2	26	81.7	111	108.4	32	−3.5	
032	F	25	147	0.44	13.4	23.9	12	76.6	106.3	38	77.0	95	101.9	32	+0.4	Hereditary lues. High diaphragm.
053	F	34	130	0.47	12.1	22.0	10	71.2	93.6	31	71.5	95	93.3	30	+0.4	High diaphragm.
052	M	16	133	0.74	13.7	24.1	14	96.3	144.4	60	99.0	130	153.3	55	+2.8	Adolescence.
03	M	39	152	0.66	13.1	24.7	6	83.0	107.1	17	83.2	95	106.7	28	+0.2	
040	F	25	120	0.60	10.4	22.7	0	68.1	84.2	24	69.9	99	85.7	23	+2.6	
057	F	33	150	0.52	12.8	23.6	9	89.3	131.6	47	87.9	107	136.5	55	−1.5	
036	F	30	100	0.36	11.1	22.0	1	66.1	91.6	39	69.9	110	96.5	39	+5.7	
033	F	49	147	0.20	14.0	24.0	17	84.6	113.2	34	83.3	103	108.5	30	−1.5	Old luetic and luetic aortitis.
042	M	87	150	0.40	11.1	26.7	0	79.6	94.4	19	81.7	99	105.2	15	+2.6	Senile heart. Underweight.
014	F	20	125	0.40	11.5	23.6	0	70.1	107.0	52	71.5	99	108.4	51	+2.0	Marked scoliosis.
S018	M	27	130	0.50	13.3	23.6	13	97.5	135.5	38	92.7	124	137.8	48	−4.0	Pulmonary tbc. Underweight.*
S015	M	30	172	0.56	13.8	24.5	12	100.9	141.0	41	102.9	113	139.7	36	+1.9	Pulmonary tbc. Outline doubtful.
062	F	26	155	0.41	14.3	25.3	13	92.1	132.5	43	89.5	105	130.2	45	−3.0	Luetic aortitis.
S08	F	26	150	0.48	13.5	24.8	9	96.2	118.9	23	94.3	114	119.3	26	−2.0	Pulmonary tbc. Underweight.*
S03	F	31	122	0.52	9.9	22.0	0	72.9	98.8	35	74.8	102	101.6	36	+2.6	Chronic pulmonary tbc. Outline doubtful.
S020	F	24	126	0.57	10.3	21.5	0	75.1	92.2	23	74.6	102	96.5	29	−0.7	
S019	M	30	152	0.59	13.2	26.8	0	103.3	142.7	38	102.1	122	145.2	42	−1.2	Pulmonary tbc. Markedly underweight.*
S022	F	24	130	0.76	13.2	24.0	10	84.1	130.3	53	84.0	112	131.6	56	−0.1	Pulmonary tbc. Underweight.*
S023	M	34	160	0.51	13.9	25.3	10	85.5	122.1	43	81.7	95	124.4	52	−4.4	Pulmonary tbc. Underweight.
S01	F	29	125	0.61	11.5	24.5	0	90.8	104.3	14	91.1	125	104.6	15	+0.3	Pulmonary tbc. Pleural effusion.
S025	M	30	140	0.83	12.1	23.9	1	88.5	124.0	40	85.6	109	128.6	50	−3.2	Pulmonary tbc.
S024	M	25	130	0.44	13.2	25.6	3	85.8	120.1	39	86.4	116	120.0	39	+0.7	Pleural adhesion at apex.
S07	F	23	156	0.52	11.1	25.3	0	82.4	121.6	47	84.0	100	125.3	49	+1.9	
078	M	40	180	0.50	15.2	28.2	8	106.8	155.4	45	102.1	110	151.3	48	−4.4	
S013	M	25	167	0.40	15.6	27.7	13	119.4	168.0	40	113.1	127	170.2	50	−5.2	Old adhesions.
064	F	18	113	0.73	10.2	22.3	0	73.7	93.9	27	75.4	110	98.2	30	+2.3	
063	F	35	118	0.64	10.6	23.6	0	75.2	95.0	23	77.0	109	97.0	26	+2.4	Luetic.
065	F	35	118	0.69	11.4	21.1	8	75.8	97.5	28	76.2	108	100.0	31	+0.5	
060	F	19	115	0.74	9.0	22.6	0	69.3	98.7	42	71.2	103	96.8	36	+2.7	
059	F	42	155	0.55	13.7	23.4	12	94.7	134.3	46	90.0	107	137.4	53	−4.9	
S010	M	45	175	0.65	13.5	26.1	3	103.1	120.9	17	101.3	110	120.5	19	−1.7	
071	F	25	130	0.59	10.1	21.3	0	77.9	87.7	12	77.0	103	89.7	17	−1.2	Luetic.
067	F	42	125	0.50	11.6	21.9	6	76.0	100.0	31	77.0	105	104.4	35	+1.3	
029	F	50	114	0.75	11.5	23.6	0	69.3	91.0	31	71.5	103	97.5	36	+3.2	
082	M	23	150	0.70	12.4	26.0	0	93.6	132.4	41	97.0	111	136.1	40	+3.6	Mild nephritis.
055	F	34	120	0.65	11.8	21.8	8	71.2	103.6	45	73.0	103	104.5	43	+2.5	
VISCEROPTOSIS																
S 02	F	23	125	0.78	8.1	23.8	0	61.0	62.5	2	62.8	90	65.5	4	+2.9	Pulmonary tbc. Markedly underweight.
S021	M	27	150	0.88	10.4	26.6	0	75.7	105.7	39	80.9	98	107.3	32	+5.5	Pulmonary tbc.
S 05	M	32	160	0.87	11.0	26.0	0	74.0	109.6	48	78.0	89	110.3	41	+5.4	Pulmonary tbc. Markedly underweight.
01	F	24	114	0.90	9.3	23.4	0	67.9	73.6	8	71.0	104	80.7	13	+4.5	
027	F	22	109	0.87	9.4	22.3	0	62.1	74.2	45	65.8	101	76.3	16	+5.9	
028	F	20	117	0.80	11.1	23.3	0	63.7	92.6	19	65.2	95	97.8	50	+2.3	
025	F	28	119	0.80	11.2	21.9	2	70.2	96.1	8	73.8	104	105.4	42	+5.1	

* Underweight. Percentages on present weight, not average weight.

† Three members of one family, apparently normal, presented large hearts. Reason undetermined. Cases prefixed with the letter S were patients at the Barlow Sanatorium for Tuberculosis. We wish to express our thanks to Dr. Munford Smith for the privilege of examining these patients.

CLINICAL CLASSIFICATION OF ONE HUNDRED TWO CASES WITH MEASUREMENTS AND COMPUTATIONS (*continued*)

Case Number	Sex	Age	Weight	A-V Ratio, Orthodiagram	Total Transverse Diameter, Plate	Width of Chest Wall, Plate	Per Cent Enlargement According to Danzer	Area Planimeter: Orthodiagram	Area Planimeter: Plate	Area Planimeter: Per Cent Discrepancy	Area Computation: Orthodiagram	Area Computation: Percentage	Area Computation: Plate	Area Computation: Per Cent Discrepancy	Per Cent Discrepancy Orthodiagram Area Using Planimeter and P.O.D.	Clinical Classification
ATHLETES																
075	M	36	198	0.49	14.6	26.9	9	117.4	142.6	21	115.4	116	146.0	26	−1.7	Stanford crew.
080	M	31	165	0.67	13.3	27.8	0	102.7	111.6	9	102.1	117	120.1	17	−0.6	Wisconsin crew.
010	M	23	143	0.73	13.5	24.3	11	94.6	122.3	29	94.2	118	128.0	35	−0.4	
09	M	21	138	0.67	12.3	25.0	0	90.6	115.0	29	93.5	120	120.2	28	+3.2	
015	M	21	150	0.85	12.3	25.6	0	95.8	118.5	25	94.2	115	121.4	29	−1.6	
046	M	40	175	0.45	14.8	26.5	12	115.7	144.3	25	119.4	120	145.6	22	+3.2	Pennsylvania crew.
034	M	26	160	0.54	14.4	27.6	4	124.8	161.0	29	131.2	153	163.8	25	+5.1	Member of B family.†
So11	M	30	182	0.39	13.6	25.4	7	110.1	139.0	26	106.0	112	143.4	35	−3.7	Harvard crew.
068	M	37	148	0.60	12.7	25.9	0	103.4	109.2	6	104.4	126	114.6	9	+0.9	
So26	M	32	158	0.58	11.8	25.8	0	99.8	110.2	10	97.3	112	113.6	16	−2.5	Chronic pulmonary tbc.
EFFORT SYNDROME																
066	F	18	123	0.74	9.7	24.0	0	63.4	96.3	52	62.8	87	87.6	23	−0.9	Pulse 150.
MITRAL STENOSIS, COMPENSATED																
022	F	29	146	1.08	12.7	25.2	1	125.2	142.2	13	129.6	160	159.0	22	+3.5	Complicated with regurgitation.
018	F	32	116	1.07	16.6	23.9	39	121.9	187.1	53	122.5	178	196.1	61	+0.5	Complicated with regurgitation.
MITRAL REGURGITATION, COMPENSATED																
058	F	42	163	0.90	14.0	23.3	20	109.5	135.9	24	110.0	127	139.0	26	+0.2	
069	M	54	245	0.51	17.4	24.9	40	132.0	203.5	54	132.7	113	199.1	50	+0.5	
056	F	25	128	0.73	14.4	23.9	20	125.5	143.2	14	123.0	167	145.1	18	−1.9	
HYPERTENSION																
070	F	57	170	0.40	14.1	26.5	7	97.0	138.6	42	95.0	106	140.7	48	−2.1	
135	F	35	115	0.45	11.2	23.2	0	86.8	96.7	11	92.3	136	101.9	14	+6.3	
012	F	59	195	0.54	15.9	24.5	29	130.9	129.0	0	129.6	132	128.8	0	−1.0	
030	M	52	190	0.51	15.6	25.0	25	102.2	125.1	22	102.9	115	125.7	22	+6.0	
038	F	41	167	0.37	14.2	23.3	22	102.2	147.6	44	106.0	119	151.7	43	+3.7	
076	M	60	150	0.46	13.8	27.1	2	110.2	130.0	18	106.8	129	130.2	22	−3.1	
MYOCARDITIS, WITHOUT DILATATION *Senile, arteriosclerotic, angina, etc.*																
039	M	55	180	0.43	15.9	31.0	2	105.5	132.6	25	105.2	114	132.7	26	−0.3	Heart block.
049	M	63	120	0.80	13.6	21.7	0	108.6	150.8	39	106.0	150	150.2	41	−2.4	Arteriosclerosis.
04	F	60	158	0.40	12.5	23.1	8	79.4	93.7	18	79.3	94	97.4	23	−0.1	Senile, underweight.
043	M	50	165	0.42	14.9	25.8	15	109.8	130.5	19	111.5	126	127.4	14	+1.5	
081	M	69	150	0.48	15.8	28.2	12	120.0	147.1	23	117.0	142	140.8	34	−2.5	Senile, hypertension.
031	F	37	169	0.55	14.2	24.8	14	104.3	116.5	11	104.5	118	115.5	10	+1.5	Nephritis, lues.
083	M	66	155	0.57	14.9	30.0	0	104.9	142.5	35	108.4	128	139.5	29	+3.3	Angina, arteriosclerosis.
037	M	47	155	0.48	13.3	25.9	3	98.2	115.6	28	104.0	125	118.7	14	+5.9	Luetic arch.
019	M	42	132	0.36	13.8	25.1	10	90.7	145.7	60	91.9	122	147.6	49	+1.3	Luetic aortitis, tabetic.
013	M	73	150	0.50	16.9	28.5	19	115.3	165.4	34	114.7	139	167.1	45	−0.5	
074	F	56	125	0.80	11.8	22.1	7	86.0	111.9	30	87.2	120	114.6	31	+1.4	
MYOCARDITIS, WITH DILATATION *Advanced stages of valvular disease, results of nutritional and toxic causes, bigh blood pressure, nepbritis, etc.*																
061	M	36	148	0.30	16.5	26.2	26	139.2	189.9	36	139.0	170	185.2	34	−0.2	Acute nephritis, hypertension.
06	M	36	148	0.40	16.6	26.0	28	150.1	164.6	9	150.0	184	168.1	12	−0.6	Acute nephritis, hypertension.
07	M	68	135	0.50	13.3	24.2	10	113.0	128.4	13	117.0	152	130.4	11	+3.5	Arteriosclerosis.
072	M	74	215	0.39	19.2	31.0	24	135.0	230.1	71	130.4	125	233.1	78	−3.4	Nephritis.
08	M	55	180	0.47	17.5	28.3	24	137.7	177.8	29	139.8	150	164.9	19	+1.5	Heart block, luetic aortitis.
017	M	60	147	0.38	15.3	23.6	30	103.7	137.0	32	100.5	124	136.4	35	−3.1	Nephritis.
050	M	62	175	0.67	15.4	27.4	13	113.1	130.3	15	113.1	121	131.2	16	−0.0	Old pulmonary tbc. with adhesions.

enlarged; and this is in fact a type of heart most frequently encountered in cases of toxic goitre.

III. THE CARDIAC MOTION

We are often told by the clinician that he cares little about the actual size or shape of the heart; that the presence or absence of a valvular lesion is of little significance so long as the heart is doing its work; that the prognosis and treatment depend entirely upon the condition of the heart muscle.

From our experience in repeated roentgen-ray observations of pathological hearts under treatment we are able to make fairly accurate estimates of how well the muscle is doing its work. We have seen dilated hearts come down from computed areas of 175 per cent to 130 or 120 per cent, and have noted corresponding improvement in the density of the lower lung fields, and in the shape, and particularly the motion, of the heart. Our roentgen-ray examinations are made independent of any knowledge of the clinical examination and have checked closely with the physical findings and the symptoms of the patient at the time. In fact, we have been able in certain instances to detect muscle failure twenty-four to forty-eight hours in advance of physical signs of dilatation.

Eyster and Meek by instantaneous radiographs of the heart have shown that the movement of no single border is an accurate index of its contraction, and that the whole outline is necessary for such estimation. However, to the experienced observer much information is derived from the movement of the various sectors of the heart. These are easily recognized, but difficult to briefly describe. One is first struck with the slight excursion to be seen anywhere on the cardiac border, and it is the general impression that the base of the heart is fixed and that the ventricular systole produces a wide retraction of the apex. However, the base of the heart is generally the least fixed portion of the organ, approaching the apex in greater degree than the apex approaches the base. The simultaneous filling of the auricles tends to prevent a reduction of the long diameter during ventricular systole. The lateral movement of the lower border being restricted by the diaphragm, the only margin of the heart that is free to move is the left upper border, its motion being a shortening of the transverse diameter. Another factor to be considered is the movement of the heart as a whole. Frequently the movement of a certain segment of the silhouette, as, for example, that sometimes seen in the left auricle in cases of auricular fibrillation and that commonly seen on the right auricular border, represents not the intrinsic movement of that segment but rather the transmitted motion of the organ as a whole. For this and other reasons, disturbances of rhythm are best analyzed by the electrocardiograph and proposed roentgen-ray methods, since such determinations, as suggested by Godht and Rosenthal in 1912 and elaborated by Crane in 1916, fail.

Certain features of disturbed motion are, however, subject to fluoroscopic examination. In visceroptotics where the heart lacks the support of the diaphragm and is freely suspended from its attachment in the mediastinum to the deep fascias of the neck, the base is relatively fixed and the heart as a whole moves as a result of the recoil from the expulsion of blood into the aorta. In the pathological heart one soon learns to recognize the disturbances of motion. The impulse may be excessive or insufficient; it may give one the impression of being disorganized or lacking in coordination or purposefulness. Thus the experienced observer readily notes the heaving impulse of aortic regurgitation, the total lack of cardiac movement in pericarditis with effusion, the almost total lack of movement frequently seen in myocarditis, and the shapeless flaccid outline with rather wavy, futile, poorly sustained impulses of myocarditis, this type most often of thyroid origin.

IV. THE AORTA

Consideration of the heart is not complete without a discussion of the aorta. Normally it is not a conspicuous shadow; its lower right border is usually fairly well seen but is soon lost in the shadow of the sternum. The transverse arch on the left is fairly prominent but is all but hidden

behind the sterno-clavicular articulation. On the screen the left lateral surface of the descending portion is usually obscured by the pulmonary and hilus shadows, but may be fairly well studied in the radiogram.

Age uncomplicated by hypertension causes an increase in the prominence of the arch throughout. Its density is increased, and occasionally calcified plaques are noted in the portions of the wall which are viewed tangentially. The arch is not greatly widened but strikingly increased in length, resulting in a greater prominence of the transverse arch and in a downward displacement of the base of the heart. The heart resting on the diaphragm consequently assumes a horizontal position. In arterio-sclerosis the aorta approximates the senile type. In hypertension the arch may be slightly widened, the upper left segment prominent with perhaps a slight increase in density. Lues shows an early tendency toward increased width of the aortic shadow, a common picture being that of the undue prominence just above the auriculo caval junction. Frequently the dilatation extends the entire length of the visible aorta. In such types of aortic change the pulsation is not excessive. Especially in the case of lues one notes a distinct reduction of the excursion. In rheumatic aortic insufficiency, on the other hand, the arch shows no appreciable dilatation, but a wide expansile excursion.

CONCLUSIONS

One hundred two hearts were examined radiographically by all the accepted methods with the following conclusions:

1. The roentgenoscopic examination of the heart is far superior to the use of the 7 foot plate.

2. A thorough roentgen-ray study of the heart embraces consideration of four elements; the shape of the cardiac shadow, its size, its motion, and the aorta.

3. The heart form is best studied by the roentgenoscope, the patient being examined in the direct and oblique positions. Changes in shape in pathological hearts are due to relative enlargement of certain chambers of the heart as compared with other chambers, and such localized enlargement is best estimated by the A-V ratio of Van Zwaluwenburg and the use of the oblique positions of Vaquez and Bordet. The roentgenoscopic examination of valvular disease adds a quantitative estimation to the qualitative findings of the stethoscope.

4. The so-called cardio-thoracic ratio is a grossly inaccurate index to the actual size of the heart.

5. There are two practicable methods of accurately estimating the cardiac size from the orthodiagram: First, the use of the planimeter; second, the simpler method of Van Zwaluwenburg, which consists of the product of the long and short diameters of the silhouette compared with the normal, based upon body weight.

6. Expression of the cardiac area as a percentage of the normal is more satisfactory to the clinician than the statement of the actual area.

7. Much information may be gained from the study of the cardiac motion by the experienced observer. One notes the force, the tone, the organization, the coordination, the presence of excessive or insufficient motion, the intrinsic motion of various chambers, and the transmitted motion of the heart as a whole, together with its relationship to other structures in the chest.

8. The aorta, which is normally an inconspicuous portion of the cardiac shadow, takes on definite characteristics in certain cardiac pathology. Chiefly among these are the changes due to age, hypertension, arteriosclerosis, lues, and pathology in the aortic valve.

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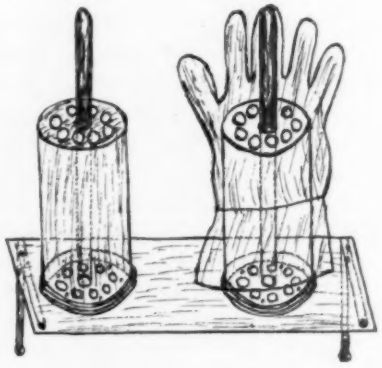
A PROTECTIVE GLOVE RACK

BY ROSCOE G. VAN NUYS, M.D.

OAKLAND, CALIFORNIA

MANY Roentgenologists find it difficult to keep their protective gloves dry inside and free from offensive odor. After trying several schemes, I hit upon a very simple one which can easily be made in any laboratory, and may solve the vexing problem for some one else as it has done for us.

It consists of two 16 ounce mailing cases (without bottles). The lids are unscrewed and tacked tightly to a shelf located over a radiator or wherever there is circulating air. Holes are made through this tin lid and through the shelf. The base of the carton is also perforated. One of these perforations should be in the center of the lid and base and should be about 1 cm. in diameter. A wooden rod 16 inches long can be tightly fitted through the inverted lid into the wooden shelf. The inverted body of the mailing case may then be slipped over the rod and screwed into the lid. The glove fits over this cylinder with the rod projecting into one of the fingers. After the gloves are dry, a little powder may be used in the glove, or a



deodorant antiseptic powder may be sprinkled into loose cotton and placed inside the cylinder. A little stain adds to its appearance.

THE PRESENT STATUS OF DEEP ROENTGEN THERAPY IN EUROPE*

BY W. H. STEWART, M.D.

NEW YORK, CITY

PROMPTED by a desire to improve our roentgen-ray therapy methods, as well as by the fact that within the past two years we have continually been hearing, from reliable sources, of great improvements in the technique and results in Germany, I recently visited the most important German Clinics. My visits seemed, in a great measure, to verify these reports.

What particularly impressed me was the excellent "team-work." It was a common observance, in most of the large Clinics, to find a physicist of no small reputation working over some problem hand-in-hand with the clinician. Such united interest is, I believe, largely accountable for the recent great advancement in roentgen-ray therapy in Germany. The general interest of the roentgenologist in the subject of physics was also very noticeable. The author attended two very interesting meetings, one held in Frankfort-on-the-Main, the other in Erlangen, at which most of the presentations dealt with physical problems. Both meetings were well attended, mostly by medical men who were especially interested in deep roentgen-ray therapy and who, despite the extremely hot weather, displayed the keenest interest in all the subjects under discussion.

Although throughout Germany a great difference in roentgen-ray technique was evident, the cardinal point, namely the administration of a "death-dealing" cancer dose, was the same in practically all of the large hospitals.

The problems on which all were working can be summed up, as Friedrich of Freiburg states, under the following headings:

1. The exact measurement of the *x*-ray dose.
2. The deep introduction into the tissues of hard, filtered *x*-rays.
3. The determination of the correct *x*-ray dose.

It is generally conceded by the Germans that the problem of the exact measurement of the depth dose has been solved by using the iontoquantimeter. This instrument has been in use for at least two years, and all agree that, with the proper care, it can be absolutely relied upon. A number of different forms of the apparatus are in use, but the one which appeals to me most is that form, modified by Friedrich of Freiburg, consisting of a small ionization chamber of graphited horn which can be placed on the skin or introduced into the vagina or rectum. This ionization chamber is connected with the charged filar system of the Wulf electrometer by a flexible cable containing an insulated copper wire, which is attached to an insulated rod of graphite in the ionization chamber. The electrometer is placed behind a lead-protective screen, where it can be seen by the operator while the treatments are being given.

Friedrich has established an electrical unit applicable to the iontoquantimeter, the full excursion of the indicator in the electrometer representing 5 such units. Experiments have demonstrated that 300 units produce death to the skin, or what is called a "necrotic dose," and about 150 units, or 50 per cent of a necrotic dose, result in a reddening of the skin, known as an "erythema dose."

Knowing that the time required for one full excursion of the indicator in the electrometer is equivalent to 5 units, it is an easy matter to determine the exposure necessary to produce an erythema dose or fraction thereof. For example, if one desiring to treat a small myoma decides that permanent castration can be accomplished with about ⅓ of an erythema dose, the technician is directed to give the patient 60 units. The time required for the administration of 60 units is determined as follows:

Sixty, the number of units to be given is divided by 5, the number of units in one full excursion of the indicator in the electrometer; this equals 12, or the total full

* Read at the Twenty-second Annual Meeting of the AMERICAN ROENTGEN RAY SOCIETY, Washington, D. C., Sept. 27–30, 1921.

excursions of the indicator in the electrometer necessary to produce 60 units of *x*-ray. It has been ascertained that one full excursion requires eight minutes, therefore, 12 excursions would require 8×12, or ninety-six minutes. In other words, it would be necessary to give ninety-six minutes' exposure in order to administer 60 units of *x*-ray.

This method of measurement seems especially valuable as the amount of *x*-ray administered can be observed while the patient is being treated.

Another popular iontoquantimeter is that model which calls for a reproduction of the electrical conditions as though a patient were being treated; the anode of the tube being set the desired distance, for example, 50 cm., from the front surface of a water-tight box, the latter representing the patient's skin. In front of this surface is placed a lead diaphragm with an opening of the size selected for the treatment field, say about 20 by 20 cm.; over the opening in this diaphragm is placed the filter; for instance, one mm. thickness of copper. Water, representing the human tissues, is placed in the box referred to above until the desired depth is obtained, say 10 cm., and back of this is the ionizing chamber connected with the electrometer. With the apparatus set in this way, one can ascertain, with the conditions as mentioned above, how much time is required, with this particular current 1, to obtain a depth dose 10 cm. beneath the skin. Tubes vary considerably, but it has been found that under the above conditions, with 180,000 volts, an exposure of about thirty-five minutes is necessary to produce an erythema. Reliance can be placed on the dose administered by this tube for some time, but it is advisable, after the tube has been in use about fifty hours, to retest it.

Still another ingenious method said to determine the depth dose is by the use of Dessauer's curves. Dessauer has devised a series of charts covering various electrical conditions, and these curves are claimed to give the operator accurate information regarding the actual percentage of the skin dose which reaches certain depths. Thus one can estimate how many fields are required, with a certain current, voltage, distance, diaphragm and filter, to administer a dose of *x*-ray sufficient to retard the growth of the cancer without destroying the normal surrounding tissues.

All must agree, whether or not the new technique explained above is accepted, that a reliable method for the accurate measurement of the depth dose is absolutely essential.

Many roentgenologists in Germany maintain that the problem of *x*-ray dosage can be considered solved, absolute reliance being placed upon the iontoquantimeter.

Regarding the *introduction of measured, hard, filtered homogenous x-rays*—this problem calls for much discussion.

Dessauer, in 1904, published his "Law of Homogeneous Radiation for Treatment." His object was evidently to control the ray to such an extent that the intensity of the dose applied to the skin surface would be about the same as that which penetrated the tissues below the surface.

Investigations along these lines were responsible for the development of a 200,000 volt *x*-ray machine, the use of which, combined with an increase in the distance between the anode of the *x*-ray tube and the skin, the enlargement of the size of the field for radiation, and the use of heavier filters (about ½ to one mm. thickness of copper or zinc) made it possible to deliver a measured dose, which had 30 to 40 per cent of the intensity of the skin dose, to tissues 10 cm. below the surface.

Increasing the distance naturally—following the law of quadratics—assisted in achieving the above-mentioned result. In some Clinics where the so-called "distance treatment" is the use, the distance from the anode to the skin is increased to 50, 60, or even 90 cm. The size of the fields have also been increased, the larger fields allowing more scattered rays to reach the central portion treated. This rule, however, does not apply to areas larger than 20×20 cm.

There is a tendency in distance treatment to ray larger and fewer areas. When only one field in front and one behind is treated, it is impossible to give the necessary lethal dose; consequently, radium is applied to make up the required amount.

When radium is not used more fields must be treated with the *x*-ray in order to deliver the 110 to 120 per cent of the skin dose which is necessary to destroy the carcinoma; this often calls for the treatment of six or seven areas.

Wintz of Erlangen states that in a field 9 × 8 cm. 18 per cent of the skin dose is delivered 10 cm. below the surface. Therefore, seven fields being rayed in the treatment of carcinoma of the uterus, he estimates that 7 × 18 per cent of the skin dose, or 126 per cent is delivered into the growth, this being considered sufficient to destroy the cancer.

There is considerable difference of opinion on the subject of filtration. Some Germans are using copper and others zinc, while in a number of Clinics, a combination of zinc and aluminum is being used; all agree, however, that their object is to obtain a homogeneity of the rays which penetrate the growth. Friedrich states that the quality of the ray is not essentially changed by increasing the copper or zinc filters to more than one mm. in thickness.

The *determination of the correct depth dose of x-ray* for various lesions, both benign and malignant, is one of our most difficult problems. It is generally conceded that it is necessary to introduce into a carcinoma at any given depth 110 to 120 per cent of the skin or erythema dose in order to destroy the growth. This is estimated by multiplying the number of fields by the percentage of the skin dose, as shown by the iontoquantimeter, which reaches the required depth below each field. The establishment of a definite carcinoma dose is almost impossible because of the great variance in cancerous structures and their radio-sensibility.

This radio-sensibility is not altogether histological, the general condition of the patient being an important factor. The skin of a cachectic patient does not always show erythema when a full erythema dose is given; in fact, subjects showing a distinct cachexia are very unfavorable for roentgen-ray treatment. We must also bear in mind that all tissues are not equally sensitive to the rays, different tissues reacting differently; for instance, youthful subjects are more sensitive than those of more mature age. Malignant growths in which connective tissues predominate require a great deal more *x*-ray than those in which the cellular structures predominate.

Carcinoma of the breast and uterus responds more favorably to deep roentgen-ray therapy than carcinoma of other organs, although some favorable results have been reported in cases of cancer of the rectum. It was found that the destructive roentgen-ray dose for the ovarian follicle is about 30 to 40 per cent of the skin dose. Permanent and temporary amenorrhea is easily established, small myomas disappearing with this same treatment. Large myomas require 50 to 60 per cent of the skin dose. In Germany the treatment of these benign conditions is considered a "closed book," so rarely do they fail to accomplish what is desired.

Sarcoma, as a rule, does not require as large a dose of *x*-ray as carcinoma, although here again the location and the histological elements, as well as the condition of the patient, must be taken into consideration; as a rule, 50 to 60 per cent of the skin dose is all that is required. Some Clinics prefer deep roentgen-ray treatment rather than operation for cases of sarcoma on account of the occurrence of metastases, it having been demonstrated that primary sarcomas, as well as metastases from same, respond very favorably to the roentgen ray.

In the Freiburg Clinic carcinoma of the breast is not operated on unless it is freely movable with no glandular involvement; all other cases being submitted for roentgen-ray treatment.

Opitz states that experimental investigations prove that a given amount of roentgen ray, if applied at one treatment, acts more favorably than if the same dose is divided over a period of time. He also states that it would be necessary to give at least 25 per cent more when divided doses are given than when one full dose is administered at one sitting; therefore, the general condition of the patient permitting, the entire treatment should be given in one day; or at least every effort should be made to administer the full dose within one week. In the Freiburg Clinic it is not considered safe to repeat an *x*-ray treatment for carcinoma within a period of eight

months. At Erlangen the treatment for carcinoma is repeated over the involved area in six weeks, providing the blood picture has returned to normal; and again in eight weeks, if the blood has regained itself.

It is difficult to ascertain during a short visit the exact clinical results of deep roentgen-ray therapy. I have found that the men, as a rule, are exceedingly conservative as to ultimate results, sad experience having taught that an apparent primary cure is often followed by an unexpected relapse; the seeming complete health of the patient not always indicating a cure.

Opitz states that he has not operated on a case of carcinoma of the uterus since 1919. His records, from January 1, 1919, to January 1, 1921, show that, in all, 60 cases of carcinoma of the cervix have been treated with deep roentgen therapy, of which 30 receded, 13 showed no improvement, 17 died, the favorable results averaging about 47 per cent. Of 30 cases of carcinoma of the fundus, 23 receded, 3 showed no improvement, 4 died, and about 80 per cent responded favorably to *x*-ray treatment.

Through the courtesy of Blumm and Warnekros of Berlin, I was able to personally examine at the University Hospital, 10 cases of receded carcinoma, 9 of the uterus and one of the vulva, all having been treated in 1913 and 1914 by the cross-fire method of *x*-ray treatment, with the old-type machine. All showed permanent skin changes at the site of the areas which had been rayed, and scarring and contraction at the location of the original lesion; none had had a recurrence.

One of the busiest clinics visited was that of Wintz of Erlangen. No statistics were at hand, that it was too early to make decisive statements about results, only two years having elapsed since the modified deep roentgen-ray treatment had been instituted. I had the privilege of examining at this Clinic one case of carcinoma of the cervix, which had received *x*-ray treatment four months previously. There was no visible evidence of the disease, the ulcerated cervix having entirely healed; considerable contraction in the left parametrium had occurred; the patient had gained weight, looked and felt well, and was free of symptoms.

Halberstadler of the Charité Hospital in Berlin gave me an opportunity to examine a number of receded cases of non-operated primary carcinomas of the breast, some of which were two or three years after roentgen-ray treatment.

Much more consideration is given to the patient than is generally supposed. It is conceded, however, that in cases of carcinoma in which the lesion calls for lengthy treatment, if successful, "the results justify the means."

In Freiburg the treatment of carcinoma of the breast requires as a rule twelve hours' exposure. The dose is divided into two day sessions; three hours in the morning, a rest of three hours and a light lunch, and three hours in the afternoon; this is repeated the next day. In some institutions, such as the Seitz Clinic in Frankfort, the patients are placed on the table in such a position that their arms are free—behind protective rubber sheeting—while the abdomen is being treated; in one instance, a patient was seen reading during the treatment. In other Clinics, particularly Erlangen, where the full dose of *x*-ray is given in one day, Pantopan-scopolamin is administered and the patient sleeps during most of the treatment. In no instance did I observe transfusion resorted to as a routine procedure.

Considerable attention is paid to the after-treatment. As Opitz states, "they are not treating carcinoma, but carcinoma-sick human beings." This after-treatment includes proper nourishment, the administration of remedies stimulating the productive energies of the body and a local hyperemic treatment of the diseased area.

In conclusion I can only state that the method of procedure, namely, the exact measurement of the depth dose, is most appealing. It is not yet safe to state that one can rely upon the iontoquantimeter entirely for estimating the correct dosage. In the hands of a responsible physicist the instrument may be reliable. It is evident, however, that future personal investigation is required before one can refuse to accept this apparently valuable method of measurement of *x*-ray dosage.

TREATMENT OF DIPHTHERIA CARRIERS BY MEANS OF THE ROENTGEN RAY*

BY PRESTON M. HICKEY, M.D.

DETROIT, MICHIGAN

IN presenting this preliminary report on the roentgen-ray treatment of diphtheria carriers, I wish, first of all, to acknowledge the active cooperation of Dr. F. N. Meader, Director of the Medical Department of the Board of Health of the City of Detroit, and also the assistance of Dr. J. Everett King, my associate, who gave personally the treatments here reported.

In the city of Detroit, during the year 1920, there were reported to the City Board of Health 4,728 cases of diphtheria. The deaths due directly to the disease and due indirectly to complications were 371. These cases were all infected by contact with those ill with diphtheria, or by contact with those who were carrying Klebs-Loeffler bacilli in their secretions but who did not present active symptoms of the disease. It is fair to assume that such statistics in varying percentages occur in many of our larger communities. Naturally these percentages vary from year to year and from season to season according to the type and virulence of the epidemic.

The efforts of the Boards of Health to reduce the number of cases and the consequent mortality consist of the treatment of those actively affected by the disease, their isolation, and measures to prevent infection from those who are diphtheria carriers by rendering their secretions free of the Klebs-Loeffler bacilli. It is found that 4 per cent of all persons in ordinary health show these organisms in the secretions of their air passages. The bacteriologic examinations of those who are associated with diphtheria cases show that 60 or 70 per cent may have Klebs-Loeffler bacilli in their nasal or pharyngeal secretions, and still present none of the clinical symptoms of diphtheria.

One of the important functions of a Board of Health, therefore, is to reduce the number of diphtheria carriers. In some communities these diphtheria carriers are quarantined as rigidly as are those who have clinical manifestations of the disease. In other communities, those of school age are excluded from attendance at school, and those whose occupation brings them in contact with food, either in its preparation or distribution, are detained from their duties. If a diphtheria case recovers and the diphtheria bacilli are found to be still present in the pharnyx of other members of the family, the quarantine on the house is raised and a warning sign replaces the quarantine card.

It requires no reflection to perceive that the treatment of diphtheria carriers and the protection of the public against these carriers constitute a difficult task for the public health officials. The administration of antitoxin does not affect the carriers, as they manifest no toxic symptoms. A great variety of local antiseptics have been experimented with, and have been employed with greatly varying successes. Of the more recent remedies, solutions of mercurochrome have proved efficacious as local applications in 60 per cent of cases. Tonsillectomy has been resorted to, but this operation cures only about 80 per cent of cases, leaving 20 per cent of a given group still a menace to the public health. There are three general types of diphtheria carriers: first, and most common, is a class in which diphtheria bacilli are found in the pharyngeal secretions; second, those in which the diphtheria bacilli are found in nasal secretions; third, those in which the diphtheria bacilli are found in the aural discharge of a chronic otitis media. Tonsillectomy has been the most efficacious of any of the lines of treatment so far employed. Still the difficulties of enforcing such a drastic line of treatment limit its use to selected cases where the consent of the patient or parent can be obtained. Naturally, among the ignorant classes, it is difficult to obtain

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the consent for an operation where the parent does not realize the menace to the public health constituted by a child who is apparently well.

The essential points of the foregoing problems were presented to me by Dr. Meader of the Detroit Board of Health. I advised the use of roentgen therapy in the treatment of these cases of diphtheria carriers. Accordingly, a number of cases were selected by Dr. Meader and roentgen-ray treatments were given over the region of the tonsils, nose and mastoid areas, according to the type of the case. The cases selected for treatment had all been studied by the bacteriologic department of the Detroit Board of Health, which department had conducted all the bacteriologic examinations preceding the roentgen-ray treatment.

In the throat cases, that is, those where Klebs-Loeffler bacilli were found in the pharyngeal secretions, the line of roentgen-ray treatment was similar to that recommended by Dr. Witherbee in cases of tonsillar hypertrophy, the treatment being given on each side of the neck, the central rays being directed toward the tonsils. The dosage employed was similar to what we had been accustomed to use for the treatment of tonsillar hypertrophy. In the nasal cases, the roentgen-ray treatment was given directly over the nose, and in the ear cases, over the mastoid area of the ear which showed Klebs-Loeffler bacilli in the discharge. Quite a few cases were treated which are not included in this report, as all which were found to give negative cultures within a few days after treatment were excluded, the belief being that they might possibly be classed under those of spontaneous recovery. Excluding those, therefore, which we did not really think should be classed as affected by the treatment, we found that there were 19 throat cases treated, with a definite cure in 15. This gives a percentage of 79; in the 6 nasal cases which are reported, 4 were cured, a percentage of 66. Nine cases of otitis media presenting Klebs-Loeffler bacilli were treated, with 4 cures, a percentage of 44. Of the throat cases which responded to the treatment, some received only one treatment, and others, two. Of the nasal cases which were cured, 3 showed absence of the bacilli after one treatment, and one case after two treatments. Of the ear cases, 2 responded to one roentgen-ray treatment while 2 others required two treatments each. The number of days required for the Klebs-Loeffler bacilli to disappear varied from three to seventeen.

The question then arises as to how many of these cases would have been cured spontaneously without the roentgen-ray treatment. This is a difficult question to answer, and one which can only be approached from the statistical standpoint. Fortunately for an intelligent comparison, we have some statistical reports of the Detroit Board of Health which were made in the treatment of diphtheria carriers by mercurochrome and gentian violet. In carrying out these studies of the treatment by mercurochrome and gentian violet, a number of throat cases were kept untreated. In all, 70 controls were observed, 34 per cent of which showed disappearance of the bacilli.

We can, therefore, summarize as follows: In untreated cases of diphtheria carriers, 34 per cent of spontaneous cures; cases treated with mercurochrome, 68 per cent of cures; pharyngeal cases treated by the roentgen ray, 80 per cent of cures.

CONCLUSIONS

1. From the Board of Health standpoint the efficient destruction of the diphtheria bacilli of the so-called diphtheria carriers is eminently desirable. It is desirable also that a treatment should be selected which can be easily applied and one which can be carried out with a minimum of distress to the patient.

2. Bacteriologic examinations show that the percentage of cures in a selected number of throat cases is greater by the roentgen-ray treatment than by the local antiseptic treatment.

3. The roentgen-ray treatment of diphtheria carriers is more easily carried out than a local treatment of the throat requiring swabbing of the pharynx, and is very much less dreaded than the operative procedure of tonsillectomy.

4. The results obtained in this pre-

liminary report justify the continuance of observations. These cases are reported in the hope that the results, added to those obtained by other investigators, will form a sufficiently large group for subsequent accurate conclusions to be made.

NOTE. Since the foregoing article was written, the author has received a number of unofficial reports from different parts of the country, stating that the results obtained by the use of the roentgen ray in the treatment of diphtheria carriers have been very gratifying. In one large city in the Middle West where 200 cases of diphtheria had been kept in quarantine for a considerable period of time and where various local methods of treatment of the pharynx had been resorted to without avail, it was found that the use of the roentgen ray was followed by a very large percentage of cases where the diphtheria bacilli disappeared from the pharynx in a very few days. These cases are being accurately studied to determine whether any considerable percentage shows recurrence of the Klebs-Loeffler bacilli.

It is the intention of the writer to collect as completely as possible the statistics from these cases and to report them in a subsequent article.

DISCUSSION

DR. WITHERBEE. The point I would like to make is that in the first 60 cases of tonsil hypertrophy I treated at the Rockefeller Institute, 36 were so infected. Thirty-two out of the 36 cases showed no streptococci or staphylococci four weeks after one dose. The roentgen ray has no electrostatic effect directly. This effect may be due to local pharyngitis or to some extent, improvement in drainage.

DR. LEDOUX-LEBARD. I have listened with the greatest interest because I had, during the war, some experience with the same treatment of diphtheria carriers. This was very near the end of the war, so that I did not feel that the number of cases I had treated, amounting to 9 or 10, if my memory is correct, was sufficient to warrant any publication on the subject. Still I think my results were in fair agreement with the results of Dr. Hickey. If I remember correctly, 7 of the 9 patients that were treated showed no diphtheria bacilli from a week to two weeks after treatment had been applied. These cases relate only to the treatment of the tonsils and throat. I have not tried treatment of the nose and ear, but I think this field seems very promising; and as Dr. Hickey has pointed out, we should go along in further experimentation, as certainly this technique will afford the best results with the least inconvenience to the patient. Of course the mechanism of the action can be discussed. There is not the slightest doubt that it is not direct action on the bacilli themselves, but is secondary action whatever the nature may be. Still I think the paper which Dr. Hickey has given us indicates great progress and would be helpful in every community interested in the treatment of diphtheria carriers.

DR. PANCOAST. There is another carrier almost equally as dangerous—the typhoid carrier. I would like to ask if Dr. Hickey has treated any cases of this kind.

DR. CLIFT. We have had no direct experience so far as diphtheria carriers are concerned, but have had rather extensive experience as regards the general subject of throat infections. Up to date we have had 69 cases of tonsil infection, either under treatment or finished. Of that number 40 have been discharged; 31 of those cases showed positive results and were clinically cured. The tonsils were smaller and examination of the cultures showed them to be sterile so far as pathological organisms are concerned—or they were very nearly so. The patients were all benefited as regards their clinical symptoms. As far as the question of otitis media is concerned, we have had rather limited experience with that. The few cases we have treated improved. In the remainder of the tonsil cases 63 were unimproved; 6 of them we have not been able to check up. Dr. Hickey's paper opens a very wide field; and from my experience, at least, I believe there is a great future for the treatment of infections of the throat. The cases in which we have not had good results are those which have had previous operation and those which have had a great deal of scar tissue in the tonsil.

MAJOR NICHOLS. This subject is one of considerable importance to the Service. Naturally we are on the lookout for anything which we can use in order to reduce the number of carriers in the Service—especially among recruits. I have been very much interested in this paper; it seems to open up possibly a new line of work. The only thing I would like to say is that it seems to me that Dr. Hickey possibly has underestimated the value of tonsillectomy. He said only 80 per cent of carriers were cured by tonsillectomy. I do not know what percentage surgeons and roentgenologists expect to get, but we think 80 per cent is pretty good. There is no doubt that the tonsil is the site where diphtheria bacilli usually remain after infection. I have examined several tonsils of

carriers and have always been able to demonstrate diphtheria bacilli in the crypt walls, as was shown on the slide. They are distinctly in the tissue and below the surface. Surface disinfection does not reach these organisms and unless we have some method of removing the crypts entirely or improving their nutrition so that they become normal, we still have carriers. We laboratory workers think if 80 per cent can be cured by tonsillectomy, it is doing well.

There are some objections to tonsillectomy, such as the dangers of anesthesia, hemorrhage, blood infection and pneumonia. The roentgen-ray treatment is a simpler procedure, but occasionally there is swelling of the parotid gland after this treatment. It seems to me that if the roentgen ray will really do this work, it will be a better method in some cases. For the Service, generally speaking, tonsillectomy offers more promise at present. Its value is proved; there is no chance of re-infection; and speed is an object. The roentgen-ray treatments cover some time. The question is, will the roentgen ray cure carriers? In reference to the series presented, one wonders what a controlled series of cases would show—that is, a control of untreated cases. If you have a carrier and do something to him one day and he is cured the next day, it is fair to believe that he would have cleared up by himself. We occasionally pick up a man who gives positive cultures of virulent bacilli for months, in spite of any local treatment except tonsillectomy. These are the cases we are after—not the early convalescent case that may clear up of its own accord.

In the middle-ear carriers, so-called, we find organisms which seem, morphologically, to be diphtheria bacilli. In my opinion, these organisms are not virulent. They are diphtheroids, and the case is not a diphtheria carrier but a case of primary or secondary diphtheroid infection.

Detroit and its representatives are to be congratulated on starting this work.

Dr. Pfahler. Major Nichols has just brought up again this subject of the swelling of the parotid gland. I have noticed this in a number of patients treated for acne and large cervical glands and I have noticed it even when the parotid gland was covered up. Therefore, I assumed it was due to some electrostatic discharge, and for this condition I grounded the lead covering the patient.

One cannot draw conclusions very easily on this subject because only a very small percentage of patients develop this condition; probably not one in 200—certainly not over 1 per cent. Therefore the absence of swelling after grounding the lead does not necessarily prove my theory.

I would like to ask Dr. Hickey how long he followed these diphtheria carriers? How long he continued cultures after the treatment was given?

Dr. Ullman. In regard to parotid swelling due to electrostatic discharge, I found it following one application of radium, as well as by roentgenotherapy. With the radium I have marked swelling lasting ten or twelve hours.

Dr. Hickey (closing discussion). In regard to Dr. Pfahler's question, these cultures were all carried out by the Board of Health nurse. We did not have a chance to follow them up. This is a very good suggestion; and in the second series of cases we will try to have them checked up.

In regard to Major Nichols' statements about tonsillectomy. I would like to state that tonsillectomy in the Army is very much more easily carried out than in Board of Health work. Take, for instance, a Polish family of children who have bad tonsils; a child is apparently well, and if you suggest that it be taken to the hospital to have its tonsils removed you have a hard time convincing the mother that it should be done. It is a pretty difficult thing to have carried out.

In regard to Dr. Pancoast's question: We have had no experience with the treatment of typhoid carriers. That is a very different program and would require more complicated technique.

Evidently there is nothing new under the sun. When one presents something which is fairly new there is always some person who has done it before. I hear, with pleasure, that Dr. Ledoux-Lebard has done this work before me.

THE AMERICAN JOURNAL OF ROENTGENOLOGY
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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

TWENTY-THIRD ANNUAL MEETING THE AMERICAN ROENTGEN RAY SOCIETY
LOS ANGELES, CAL., SEPTEMBER 12, 13, 14, 15, 16, 1922
Headquarters, Meetings and Exhibits: Hotel Ambassador, Los Angeles, Cal.

THE HEART, THE *X*-RAY AND THE INTERNIST

THE able and comprehensive paper by Karshner and Kennicott in this issue brings up the subject of the *x*-ray examination of the heart for thoughtful consideration. It is now more than a quarter of a century since the pulsating outlines of the heart upon the fluorescent screen first aroused the startled expectations of medical men. During this period roentgenologists have spent much time and ingenuity in developing and systematizing methods of cardiac study until today it is fortified by an extensive literature which has made available a large collective experience and a large body of accurate data.

Yet it is not a generally accepted nor much used method. Internists are perhaps superabundantly supplied with instrumental means of examining the heart. The stethoscope, the percussion hammer, the sphygmograph or polygraph, the blood-pressure manometers and the electrocardiograph somewhat deter the internist from feeling the need of another and more elaborate instrument. Many able and successful men admit the importance of these instruments for purposes of research but use the stethoscope merely as a sanitary convenience, holding that the palpating finger and the ear are the only necessary instruments for the examination of the heart. The *x*-ray, to be sure, is accepted for the detection of aneurysm and to a less extent for the estimation of the size of the heart, but the same hard-headed conservatism which impeded the use of the thermometer, the stethoscope and other instrumental methods is still as active in some quarters as it was in the days of Wunderlich and Laënnec.

In no department is the *x*-ray revision of internal medicine more inevitable and less acceptable to internists than in the examination of the chest. Barium or bismuth for the alimentary tube, oxygen or carbondioxide for pneumoperitoneum, sodium iodide or thorium for the urinary tract, suggest the technical requirements of later *x*-ray work, but the chest without any preparation excepting a full breath provided perfect conditions for *x*-ray study from the beginnings of clinical roentgenology. The work below the diaphragm has met with enthusiastic reception; the *x*-ray examination of the lungs has won a tardy recognition; but the examination of the heart by screen or plate is apparently still on trial.

Sir James Mackenzie has thrown the weight of a mighty reputation into the following statement in "Oxford Medicine," of which he is senior editor: "The inspection and palpation of the movements of the heart and the percussion of the heart's dulness give a far more valuable indication of the size of the different chambers of the heart than an *x*-ray examination. Indeed I am doubtful if any *x*-ray examination of

the heart has ever thrown the slightest light upon any cardiac condition." ("Oxford Medicine," II, pp. 456–457). Such a sweeping and unqualified condemnation by one of the foremost of English-speaking internists in one of the very latest and most extensive works on general medicine compels us to pause and consider whether or not the *x*-ray examination of the heart is really worthwhile and whether or not we can justify the faith that is in us.

A little investigation in several fairly recent books on the heart which happen to be at hand, shows that Mackenzie is not alone in his opinion. Four of these books, all well known and authoritative, quietly and almost completely ignore the *x*-ray. One is embellished by a number of *x*-ray plates of the heart which are not referred to in the text. A fifth work, however, one of the recent systems of practice, contains an extensive section on the heart in which the *x*-ray findings are incorporated with other diagnostic data under each cardiac affection. This is done with a discrimination and knowledge that does much to restore our confidence in the final recognition of the *x*-ray in this stronghold of the internist.

A very brief general survey may help us to understand the attitude of authors both for and against the roentgen-ray method of examination. To this end we may assemble the well-known signs of heart disease and specify those which may be demonstrated by the *x*-ray tube. We may then ask ourselves, which of these signs can be demonstrated only by the *x*-ray; which can be thus demonstrated best although also detectable by clinical methods, and which of these need *x*-ray confirmation? We may further ask in what cases the *x*-ray may be unnecessary because less expensive methods reveal, equally well, the cardiac signs; and finally we must answer the ever-repeated question, Is the *x*-ray sufficiently available so that the internist can rely upon it in his daily work?

We believe that these questions may be answered fairly in favor of the *x*-ray method, but we cannot, in the limits of an editorial, do more than indicate by outline what such answers would be. The familiar signs of heart disease are the alterations of size of one or more chambers, the location of the apex beat, the presence of murmurs, clicks, bruits, pain, palpable thrills, irregularities of the heart beat, alterations of "blood-pressure," changes in electrical potential, fluid in the pericardial sac, pericardial adhesions or calcifications, the reaction of the cardiac muscle to forced exercise, dyspnea, the character of the respiration, the color of the skin, the size of the liver, and edema of the extremities. It is at once apparent that the *x*-ray cannot claim to be a substitute for a clinical examination, and any argument against the *x*-ray, based upon an assumption of such claims is most unfair. The *x*-ray is to be used in conjunction with the clinical examination on the same terms as the stethoscope. It is obvious that heart tones and murmurs can be studied only by the ear; a thrill can be detected only by the sense of touch; dyspnea and pain can be realized only by the patient; blood-pressure, electrocardiograms and other tracings can only be obtained by special instruments; and that the character of the respiration, the size of the liver, edema of the extremities and cyanosis are properly matters of clinical observation. This leaves for possible *x*-ray study, alterations in the size of one or more chambers of the heart, the form of the heart silhouette, the position of the heart within the chest, the movements of the heart, fluid or gas in the pericardial sac, adhesions or calcifications and also aneurisms of the arch or dilatations of the thoracic aorta. These last are included because the condition of the aorta is inextricably interrelated to heart disease. The scope of the *x*-ray examination is in reality somewhat larger because congestion of the lungs resulting from cardiac decompensation, pulmonary infarct from emboli and tumors within the chest, confusing cardiac dulness, may at times require *x*-ray assistance.

The heart signs which can be demonstrated only by the *x*-ray are the form of the heart, the pulsation of each chamber separately, calcifications of the pericardium or aorta, small aneurysms and dilatations of the thoracic aorta. The accurate determination of the size of the heart

can be made only by *x*-ray methods. It is not too much to say that the clinical estimation of heart size is grossly inaccurate by comparison. A study of the paper by Karshner and Kennicott or of the monograph by Vaquez and Bordet will convince the reader that the determination of heart volume is exclusively an *x*-ray problem. The earlier papers of Van Zwaluwenburg and Bardeen had already given us practicable clinical methods.

The study of the form and movements of the heart is much more complicated and less perfectly developed than the determination of size. The recognition of characteristic forms indicative of various cardiac affections requires not only a large roentgenological experience but also training in the diagnostics of internal medicine. Heart form varies with the plane of the silhouette, with the posture of the patient, with the extent of the respiration, and with each point in the cardiac cycle. Instantaneous exposures timed by the pulse have added to our powers of interpretation. A succession of such views analyses both form and motion. A selection of views to complete a cardiac cycle have been used to gain a cinematographic effect. The direct screen view of the heart is a perfect moving picture, but a proper film which could be "slowed down" would be of inestimable value in the study of auricular fibrillation, heart-block and other arrhythmias. We believe that such cinematographic films will be possible when a sufficiently large lens of lead glass can be placed between the moving picture camera and the fluoroscopic screen so as to gather and concentrate the relatively feeble light of the screen upon a suitable lens system in the camera. Possibly a large reflector such as is used in telescopes could be adapted to the gathering and concentration of the fluorescent light.

A study of "slowed down" heart movements may be effected in another way which has already been demonstrated experimentally. This is by the slit tracings first described by Gocht and Rosenthal. The heart is covered by lead excepting for two or three slits at right angles to pulsating edges of the heart shadow. The speed of the film as it travels over these slits determines the elongation or "slowing down" of the resulting tracings. Such tracings are records of pulsating muscle movements and give a different set of factors from polygraphic tracings which record variations of tension within the chambers, or from electrocardiographic tracings which record variations of electrical potential at the two poles of the heart. Simultaneous tracings from opposite sides of the heart, as, for examination, from the right auricle and left ventricle, distinguish mass movements from pulsation movements. The adverse criticism by Karshner and Kennicott of *x*-ray slit tracings seems to us to be prejudgment delivered theoretically in advance of any proper clinical investigation. Such an investigation can only be made after some manufacturer has provided us with a suitable type of instrument; and until this is done a final verdict should be withheld.

However, without borrowing from the research of the future, the roentgenologist today is able to interpret his screen observations of form and movement in much the same way that the internist interprets the sounds heard through his stethoscope.

We do not mean that the *x*-ray screen can or should replace the stethoscope. On the contrary, the best screen work can only be done in collaboration with auscultation. The practice of listening to the heart sounds while making a screen observation should be routine. A series of sign-complexes for heart affections, similar to the Holzknecht symptom-complexes for diseases of the stomach, were outlined by the writer some years ago.* These were based on a combination of auscultatory and *x*-ray signs, as for example:

Group with Systolic Murmurs
- Dilatation of right auricle.
- Ventricular type of the right auricular pulse.
- Hypertrophy of the right ventricle.
- Venous pulse in the right jugular.
- *Diagnosis:* Tricuspid regurgitation.
- (Murmur absent in most marked cases.)

X-ray signs of heart disease are of course not infallible. Murmurs also are not

* Roentgenology of the Heart. AMER. J. ROENTGENOL., Nov., 1916.

always significant of disease. This is especially true of murmurs heard over the left base of the heart—that area called by Balfour the region of "auscultatory romance." Doubtless many an able man, during the World War, was rejected for military service because of a questionable murmur. If, in such a case, the *x*-ray had demonstrated an enlargement, then the murmur could have been considered pathological. Also if the pulsations of the left ventricle were found of sufficient grade and were seen to be synchronous with the ventricular beat, then the murmur must have been due to mitral regurgitation. Examples could be multiplied. Thus the *x*-ray may endow old signs with new significance and add new determining factors to the cardiac symptom-complex.

It cannot be disputed that there are certain cases of heart disease where the *x*-ray examination will add nothing to the diagnosis. This, however, cannot always be predicted. Certain complications already mentioned cannot with certainty be excluded excepting on the *x*-ray table. In chronic cases it will be rare that the *x*-ray does not add or confirm some sign of value. In reaching this conclusion we are giving our answer to Mackenzie and others who would deny to the *x*-ray any place in the examination of the heart. We do not undervalue clinical methods, but such is the supremacy of the eye and such the importance of things seen that the roentgen-ray image will take an assured precedence as diagnostic evidence.

The question of expense or availability of the *x*-ray in affections of the heart has been fully and practically answered by cases of pulmonary and gastro-intestinal diseases. We doubt if patients with heart diseases are any less willing to be examined than those with tuberculosis or peptic ulcer who now make up so large a part of the roentgenological clientele.

The paper by Karshner and Kennicott should be read by clinicians as well as by *x*-ray specialists. The dissemination of such knowledge will increase the frequency of consultations on equal terms between internists and roentgenologists. The precision of instrumental methods must not obscure the larger fact that the recognition of a valve lesion, a myocarditis, or an enlargement is not the practical end of a diagnosis. Efficient therapy requires the etiological factors. Is it a thyroid heart, a luetic heart, a toxic heart or is it the result of a focal infection, a nephritis or an arteriosclerosis? These and similar factors must be sought but they will not be found by the stethoscope alone or the *x*-ray alone or the electrocardiograph alone. A competent clinical survey requires a reliable case-history, which is, in the last analysis, the fundamental document of diagnosis.

A. W. Crane.

The following letter by the late Dr. Van Zwaluwenburg is so characteristic of the man and so intrinsically valuable that we believe it will be of general interest. This letter is a model of what correspondence between men of science should be but rarely is in these practical days. To be the friend of such a man was indeed a privilege.

Department of Roentgenology,
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My Dear Dr. Crane:

I am so little satisfied with the outcome of my criticism of your excellent paper, that I am writing you somewhat at length, not so much in apology as in explanation. The time was so limited and I felt so much the need for brevity that I perhaps was not entirely clear in what I said.

My main criticism is not with the method for the determinaton of the size of the heart, but with an examination that is limited to the determination of the size, whether the area or its linear dimensions. The work of the French, especially, has been very valuable, and includes the observation in the oblique positions, the determination of the angle of disappearance of the apex behind the vertebral shadow, the mobility of the apex and the diaphragm, and a study of the action of the heart itself. The estimation of the size of the left auricle in the oblique position gives us a pathognomonic picture for mitral stenosis, for instance; a diagnosis that is most problematic by any other means. The study of the arch of the aorta also is perfectly feasible and very productive. But, I need not go into a detailed discussion of the method to you. I should

like to refer you to the latest edition of the monograph of Vaquez and Bordet—"Le Coeur et l'Aorte." The advantages of a thorough roentgenographic study of the heart is there well discussed, and I can testify from personal experience covering a number of years, to the value and accuracy of the method.

Now as to the accurate determination of the size of the heart, in my opinion one can very well carry that to unnecessary refinements. After all, you and I know that the heart is subject to numerous and sudden changes in size under various conditions, besides the normal personal variation with age, weight, stature, occupation, etc. Moreover, in the estimation of any diameter or area, one need not have the absolute value in order to reach conclusions of real value. It is perfectly satisfactory to determine some value that presumably varies as the value with which we are seeking and comparing it; a "norm" that one has reached by the examination of a sufficient number of healthy individuals. So, if the length of an individual can be satisfactorily estimated by measuring the length of the femur—and this is the more convenient procedure—there is no real and serious reason why the femur should not be accepted as the yard-stick for the individual. Hence, it does not matter so much whether the area as described by Bardeen actually represents the projection of the sagittal optical cross-section of the heart, as whether that value is increased or otherwise modified in comparison with the norm which we have determined by an actual calibration of the method.

In case I concede that Bardeen's outlines more nearly represent the outline of the heart, let me call your attention to the fact that their construction is more difficult than the usual one as practiced by the fluoroscopic method. On the screen the upper border of the left ventricle is easily followed for some little distance into the median shadow above the base of the heart. The faint shadow above this line represents a comparatively thin section of the left auricular appendix, one that represents relatively more of the area of the heart than of its volume, and one that is of little interest to the examiner. Why include a faint shadow in the area of the heart rather than in its volume, and why include it when it is of little interest to the examiner? Why include it in the area under consideration? There is a very good reason for excluding it.

In the fluoroscopic examination one can always determine the junction of the ventricle and the auricle on the left side, a point which is most important in judging the relative distentions of the two. On the plate, this identification is usually quite impossible and always somewhat uncertain. But if we exclude this area from the determination, the shape of the heart is almost an ovoid, easily reconstructed, and its area can be estimated without the use of an expensive planimeter, by simple calculation. This estimation has an error of not more than 5 per cent of the total, an error that is well within the normal variations and therefore probably negligible.

As to the possibility of comparing the orthodiagram and the teleoroentgenogram, I can only say that I have never had any sort of success at it. It may be that I see something quite different on the screen than appears on the plate. It is a matter of sad experience that I have never succeeded in teaching a student to inscribe the same figure that I see. To be sure, I have never had a student who would stay by the job long enough to learn to discriminate, although I have had at least one man who had excellent heart training in internal medicine. At first a man "goes wild" on the numerous shadows of the lower thorax, all of which are moving in synchronism with the pulse beat, but in time he learns to see a figure that for him at least is normal. Whether or not this is the actual outline of the heart is another question. But for practical purposes and by comparison with other figures they probably have a similar value with my own. I have to admit that the method is not without its subjective elements.

I have repeatedly tried to duplicate my figures by the long distance methods and failed. I do not know why. Even at 9 feet, the shadow on the plate usually exceeds that of the orthodiagram by from 6 to 15 per

cent. The same error appears in the outlines of the chest wall. I am inclined to think the discrepancies are due to slight differences in the position of the patient with reference to the plate, and of the stage of the diaphragmatic excursion. I have not been able to make the antero-posterior agree with the plate in the opposite direction. I have attempted to simulate exactly the same inclination of the thorax to the vertical and to the plate.

I may tell here of the difficulty Dr. Hewlett and I had with an "Arbeit" we undertook some two years ago. We ran the patient on a bicycle fitted with a friction drum in an effort to produce a dilatation of the heart under strenuous exercise. The plate was strapped to his chest which was fixed by rigid supports. We passed a wire about his chest to insure a similar respiratory position; we made one second exposures with the breath held, and then we had so many factors to consider that we were never sure we had produced a dilatation. As a matter of fact, the average of several sets of plates seemed to show a reduction in the area and in the linear dimensions of the shadow during the stage of severe dyspnea, but the individual variations were much in excess of the average and both ways of the rule. We were inclined to attribute the apparent reduction of size to the tachycardia produced. It is, of course, an old observation that the increased rate is associated with a demonstrable reduction in the area of the heart. (This, by the way, is a factor not considered in the work LeWald showed us.)

As to the reconstruction of the heart figure by the method you proposed, I still maintain that it is not a mere matter of mathematics, if you insist on a rigid interpretation of your findings. First, it will be necessary to make your plates with the body rigidly in the same position with reference to the vertical, not leaning against the plate. Next the two plates will have to be rigidly orientated with reference to the normal ray, or your corrections, while in the main correct, will still produce some distortion in the reconstructed figure. Lastly, a reference to the enclosed rough sketch will show that you record the tangential rays, which intersect at B and B′ at a point outside the true figure (in this case a circle), and at a distance of AB and A′ B′ in excess of the true diameter. The error is not large, to be sure. But in addition, one must remember that the heart is not spherical, but under pathological conditions may vary considerably from the "round," under which circumstances the error would be greater. How shall we compare this with the transverse?

I realize that this criticism is a refinement that the conditions do not justify, and as an approximation your method has many things to recommend it. It would ill become me to criticize, anyway. It may interest you to know that three of the four American articles quoted by Vaquez, were (1) Crane, (2) Van Zwaluwenburg and Warren, and (3) Bardeen.

I think my irritation is altogether in consequence of the failure of the medical profession to recognize the value of this method of cardiac examination. Undoubtedly men have not wished to take the time to learn the trick or to do the work when other more immediately profitable work was at hand. Besides, few roentgenologists have the necessary preparation in medicine to interpret their findings when they get them. The electrocardiogram has a more limited application, and furnishes less information than the orthodiagram, but is universally accepted as a necessary means of diagnosis, while the orthodiagram is so little known that the medical examiner at Camp Custer confused it with the electrocardiagram, and it went through three medical hands without detection.

I have been much amused at the attitude of the men who have come to our clinic from elsewhere. When they first arrive, they are always skeptical of the method; their opinion being that it is good enough to show the students and to correct the percutory findings, but not really contributing to the sum total of our knowledge of the case. After they have been here a while, the number of cases increases; cases are referred that have no cardiac condition, etc., in the natural sequence of events. Ultimately they all come to the conclusion that the method adds more value than any other laboratory method

to the examination of cardiovascular conditions.

Usually the men want to see for themselves, but after a few attempts on their part conclude it best to take my word for it. Dr. Newburgh is enthusiastic, and Dr. Farr spent four weeks with me to study it.

I know you will not think me impertinent for writing you this, which, after all, is a very unsatisfactory exposition of my opinion in regard to the method. I should like nothing better than an opportunity to discuss it with you and a few others, "in camera," with sufficient time to really cover the subject. I should like to show some of the orthodiagrams I have on file, to illustrate the limitations as well as the applications of the method. I feel that what we need is not so much a refinement of the method as a more thorough application of the means already at hand and a more thorough understanding of the logical inferences. Maybe I'm wrong!

I have not had opportunity to express the pleasure I experienced at the Detroit meeting. It was one of the most enjoyable I have attended. I only regret that I could not stay to see the lantern-slide exhibit finished. Let me also thank you for the courtesy of advancing me on the program so that I could catch my train. As it was, I just made it with nothing to spare.

Practice is heavier and more exacting than ever and I am regularly working overtime. I hope to find some relief this summer.

Yours sincerely,

VAN.

March 28th, 1919.

CANADIAN RADIOLOGICAL SOCIETY CONSULTATION BUREAU

The Canadian Radiological Society has established a Consultation Bureau where any and all questions pertaining to *x*-ray and radium may be submitted for information, suggestions, or advice.

We quote from the announcement:

"One of the chief objects of the Society is the maintaining of a thoroughly ethical standard in this special branch of medicine in Canada, and providing any practical assistance that they can offer toward that end. This is being done cheerfully and entirely without charge, and in doing so it is of course obvious that there is no mercenary motive whatsoever. The idea underlying the establishment of this bureau is that the members of the society, being specialists in this branch, are best able to assist you in these matters,—so therefore, whether it be the selection of apparatus, difficulties in operation, or other points of a technical nature or otherwise, the resources of the society are being offered to you for the asking."

As we go to press, word is received of the death of Prof. John S. Shearer at his home, Ithaca, N. Y., May 16th, 1922.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY *visiting New York City, are invited to make the office of* THE JOURNAL (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

TRANSLATIONS & ABSTRACTS

BARJON. Radiodiagnosis of Pleural Symphysis. (*Paris méd.*, February, 1921, ii, 6.)

By symphysis is meant the adhesion of the two laminae of the pleura to each other, which leads to a certain amount of fixation of the lung and thoracic cavity, either total or partial. It is the cicatrix resulting from inflammation of the pleura or lung, and the process of inflammation may be still active or extinct. It is found in the most varied inflammatory and neoplastic conditions, but is itself silent, giving rise to no clinical manifestations. In physical diagnosis it gives rise to diminished resonance and vocal fremitus and lessened breathing. If the subjacent lung be healthy, there will be no reason to suspect pleural adhesion; while if it be diseased, the signs of the affected lung tissue mask its presence. In extreme cases of adhesion and cicatricial retraction the thorax is deformed and retracted, with or without deviation of the heart.

Pleural symphysis is often looked upon as a conservative effort of nature rather than as a disease, for it may, for example, prevent the perforation of a cavity. Chiefly in connection with the operation of artificial pneumothorax is it advantageous to know whether the pleural laminae are adherent, for this constitutes a contraindication. Hence the use of radiography before this operation. In the routine use of the rays in the diagnosis of tuberculosis it is also of importance to note the presence or absence of adhesions. In radiographic diagnosis the bases of the lungs are most readily studied for the presence of adhesions. If these are present, the sinuses will be effaced while the diaphragm may be fixed.

The author has studied 24 cases of adhesions from this double viewpoint. The costodiaphragmatic sinuses may be completely or only partially obliterated, or normal. In the first case there is seen on the plate total opacity of this portion of the pleural cavity. There may be a certain amount of exudate as a result of the inflammation which has produced the adhesion. This, little by little, will push back the pulmonary lamina until it is completely dislodged, as a result of which the sinus is the seat of total opacity with loss of its contours. At times the diaphragm loses its convexity, for fixation of the external border to the parieties of the chest has deprived it of mobility. Nearly always in such cases the lung preserves towards its base a certain luminosity, and a clear band is defined immediately above the diaphragm. The opacity of the sinus is due to the fact that the lung has been dislodged from it. It is necessary in these cases to exclude the possibility that the opacity could be due to a lesion of the base of the lung. In pleural exudation, the shadow is much more compact and homogeneous, with complete obliteration of contours.

If the sinuses appear perfectly normal on the screen we cannot exclude the presence of adhesions, for in 25 roentgenoscopies of apparently normal individuals symphysis was later shown to have been present in 10. A positive result on the other hand is conclusive. The importance of immobility of the diaphragm for the diagnosis of symphysis is not great, because this condition occurs under a variety of circumstances. In 20 cases of symphysis the diaphragm was immobilized in but 3. The author concludes that the disappearance of the image of the sinus has great, and at times pathognomonic, value, especially when the symphysis is partial; although negative image does not imply absence of symphysis. The author emphatically denies that with a clear base, normal sinus and mobile diaphragm, one may be certain of the success of an artificial pneumothorax; cases undoubtedly exist in which symphysis is present, despite these findings.

W. E. LOWER. Diverticula of the Urinary Bladder. (*Arch. Surg.*, July, 1921.)

The author describes the structure and location of diverticula, discusses the etiology and gives the views of various writers, as well as his own, on diagnosis of the condition. There is a consensus of opinion that a fairly accurate diagnosis can be made by the aid of the cystoscope and cystography. Howard uses a 10 per cent thorium nitrate and Rathbun a 25 per cent sodium bromide solution for cystography. Cystograms should be made in two diameters and stereoscopically.

Treatment consists in excision, and relief of any obstruction that is present. The writer describes the method of excision in use in his clinic.

The prognosis, as a rule, is favorable. Immediate mortality rate should not be great if the patient is properly prepared by clearing of infection, and the kidney function assured.

Radical operation furnishes so much greater relief than palliative measures that the former is always the method of choice.

A. C. C.